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SCHOOL SCIENCE AND MATHEMATICS

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A Journal for all SCIENCE AND MATHEMATICS TEACHERS

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New Principles of Oil Burners

Great Turning Points in Astronomy

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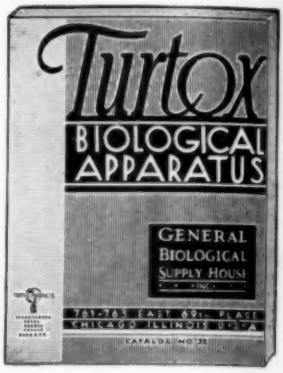

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XXXI NO. 7 OCTOBER, 1931 WHOLE NO. 270

BOIL IT DOWN.*

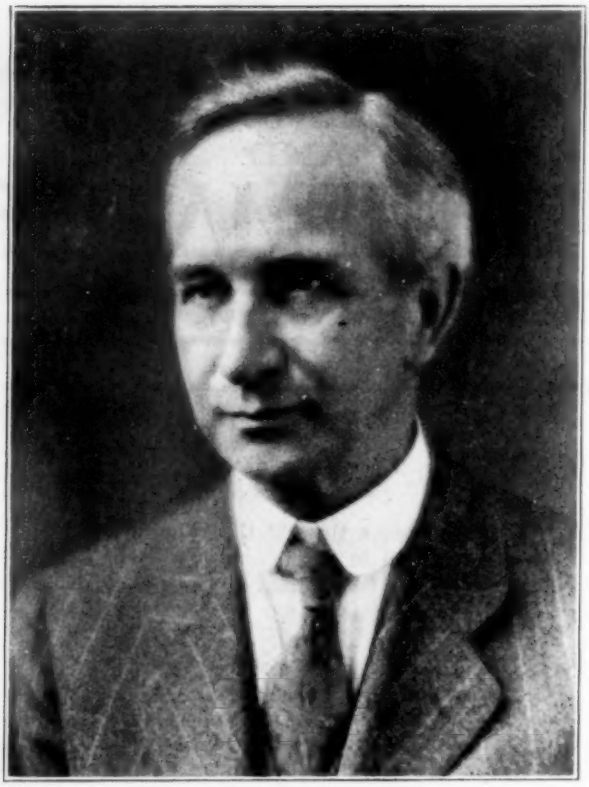
By JOE LINCOLN.

If you've got a thought that's happy,
Boil it down;
Make it short and crisp and snappy,
Boil it down;
When your brain its coin has minted
Down the page your pen has sprinted—
If you want your product printed
Boil it down.

Take out every useless letter,
Boil it down;
Fewer syllables the better,
Boil it down;
Make it plain, express it
So we'll know, not merely guess it;
Then my friend ere you address it,
Boil it down.

Boil out all the useless trimmings,
Boil it down;
Skim it well, then skim the skimmings,
Boil it down;
When you're sure 'twould be a sin to
Cut another sentence into two
Send it on and we'll begin to
Boil it down.

*This poem was sent by a friend who did not give us the name of the original publisher, if any. If any reader will send us the publisher's name we shall gladly give proper acknowledgment.—Ed.



CLARENCE LEE HOLTZMAN

Teacher Scientist Educator

Clarence Lee Holtzman died August 2 of heart failure at the home of his son, Dr. C. W. Holtzman, Minneapolis, Minn., at the age of 60.

He was born at Bloomington, Indiana, and was educated at the University of Indiana, graduating in 1892 with the degree of A. B. Later he attended the University of Chicago, and received the Masters' degree in 1901. In 1903 he came to the Waller High School, Chicago, as teacher of Biology and later became Assistant Principal; here he remained until 1930 when he was made Principal of the Motley grammar school.

For 28 years he was a member of both the Chicago and National Geographic Societies. He was on the Board of Governors of the Chicago Academy of Sciences. In

1904 he joined the Central Association of Science and Mathematics Teachers and was one of its most active and loyal members, and was its President during 1924. When the association purchased this journal in 1928, he cooperated and was one of the first debenture holders that made possible its purchase.

Always very active in the Biology section, his name appeared on many of its programs. In 1919 he was chairman of the section. At all times he was ready to give his best effort and judgment to the association.

By his associates he was considered one of the best Biology teachers in the city. Zoology was his specialty. He believed in having his pupils learn by handling the real live material for themselves, not by reading alone, from the textbook. While at the Motley school he emphasized nature study in the grades so that both pupils and teachers became enthusiastic nature lovers.

His friends always found him untiring in his efforts for help; always making sacrifices for others. And so another worthwhile life has been spent, leaving memories which many will cherish.

A LETTER TO THE MEMBERS OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

By G. W. WARNER, PRESIDENT.

You are of course planning to attend the annual convention at Chicago next November the 27th and 28th. The program includes lectures by internationally known men from three great universities and from two giant industries. The section meetings provide for exchange of practical teaching plans.

The meeting will be held in Chicago's newest high school building. The arrangement of class rooms and laboratories, the equipment, study rooms, gymnasiums, and decorations are the latest word in design and workmanship. The principal of the school is a former member of this Association and the vice-principal is a past president. Everything possible is being done by the local committee for your entertainment and comfort.

In your official journal, SCHOOL SCIENCE AND MATHEMATICS, you have received since last October 100 pages of excellent articles more than the normal amount. Help the membership committee and you will get still more next year. Enroll all the science and mathematics teachers in your school who are not now members. Use the blank on page 905 of this issue.

The great metropolis of the lakes has opportunities and attractions not duplicated anywhere. This meeting will give you an opportunity to visit the Adler Planetarium, the Shedd Aquarium, the Field Museum, or the great libraries. You may want to enjoy Thursday or

Saturday night at the opera or to see the replica of old Fort Dearborn or the other buildings completed or in process of construction for the Century of Progress Exposition. All this will cost little extra in time or money and both the immediate and ultimate return on your investment will be gratifying. The big question for teachers in all the Central States and farther away is not "Can I afford it?" but "Can I afford to miss it?"

By order of the Board of Directors of the Central Association of Science and Mathematics Teachers, Inc. the President appointed a committee to study the By-Laws of the Association and recommend changes. This committee was appointed and submitted the report which is published below. All members are requested to study these proposed amendments and to attend the 1931 Annual Business Meeting Saturday, November 28, prepared to vote for or against their adoption.

PROPOSED AMENDMENTS TO THE BY-LAWS OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

The following sections shall read as follows:

Article 2, Section 3. Twenty-five members present at any regular meeting shall constitute a quorum.

Article 2, Section 7, Proxies. All members entitled to vote may cast their votes in person or through a duly accredited proxy.

Article 3, Section 4, (c). Secretary. The Secretary shall keep all the records, minutes of all meetings and shall prepare and submit a complete report of the annual meeting to the editor of the journal by December 31st following the meeting. He shall have charge of the permanent offices and manage the affairs of the Association under the direction of the Executive Committee.

Article 3, Section 4, (d). Treasurer. The Treasurer shall collect all dues and hold all moneys and keep a record of all receipts and disbursements. He shall give a detailed report at each meeting of the Association. He shall pay out funds on the order of the Board of Directors and the Executive Committee.

Article 3, Section 4, (e). Editor and Business Manager. The Editor and the Business Manager of the journal shall be elected by the Board of Directors. Their term of office shall be indeterminate at the pleasure of the Board of Directors.

Article 3, Section 4, (f). Fiscal Year. The Fiscal year shall be from July 1st to June 30th.

Article 6. Amendments. The By-Laws may be amended by a two-thirds (⅔) vote of the regular members present at any regular meeting of the Association or at any special meeting of the Association called for the purpose of voting on such amendment provided the proposed amendment has been published in two successive issues of SCHOOL SCIENCE AND MATHEMATICS.

CLARENCE L. HOLTZMAN, *Chairman.*
CHARLES M. TURTON,
WALTER G. GINGERY.

CURIOUS ANSWERS.

Question: "What causes the report, as of a gun, when an electric light bulb is shattered?"

Answer: "Interference of the light waves and the sound waves, producing a racket."—From a pupil in the Brookline High School.

GREAT TURNING POINTS IN ASTRONOMY'S HIGHWAY.*

By G. W. Myers,
The University of Chicago.

Introductory

Industrial leaders tells us that more industrial advance has been made the last twenty years than in any preceding century. So rapid is advance today we are told, that he who believes industrially what he did one year ago is slipping,—fossilizing. History here antiquates as soon as it is made. Not so however in astronomy. Like the worlds it investigates, the development of astronomy is leisurely, deliberate, continuous and cumulative from age to age. In the process of sloughing surface error and of husking out the central core of truth which is astronomical progress, history is meaningful, significant. Even though scientific knowledge in some lines may have begun with the twentieth century, scientific astronomical knowledge far antedated the opening of this wonderful century. A modicum of the tolerance befitting to youth is accordingly hereby invoked for a few fleeting glimpses along time's corridors.

It's a long lane that has no turning, but I am to speak of a long lane that has many turnings. You will agree to the length of the lane at least, when you are reminded that it goes back through the war-torn periods of mediaeval Europe, through the dark ages, past the great days of Greece and Rome, on through the ages when Nineveh and Babylon were commercial and cultural centers of world renown, back across the epoch of the great pyramid builders of Egypt, back finally to that remote period of Egyptian civilization which was just dawning along the lower Nile some six or seven thousand years ago.

Pre-Grecian Astronomy

Several years since in a book which he called "The Dawn of Astronomy," Sir Norman Lockyer gave a detailed account of a very careful study and survey extending through several months, of the orientation of monuments, temples and public edifices of the early Egyptians. He reports that the manner of orientation of their religious and memorial structures falls into three distinct periods. During the earliest

*Read before The Round Table Club of Bryn Mawr Community Church, Chicago, Jan. 25, 1931.

period closing some 3000 B. C. foundation ruins show that important edifices were always oriented to the solstices, i. e., they were so placed that the rays of the rising or setting sun on the day of the summer or winter solstice, would pass along the nave and fall directly upon the altar. During the second period such edifices were oriented to the equinoxes, i. e. to the rising and setting points of the sun on the days of the equinoxes. During the third epoch which was the epoch of the pyramids, orientation of important structures was to the then north star, or as we say, to the meridian. These facts make it evident that the Egyptians at a very early age had a practical acquaintance with the positions and movements of the sun at least, and perhaps also of other heavenly bodies.

The two facts, that the religion of the Egyptians of these periods was sun- and moon-worship and that the annual inundations of the Nile were timed regularly with certain positions of the sun, drove them to make and to keep very careful records of the positions and movements of the heavenly bodies. Such records were essential both to their religious observances and to the daily round of their seasonal activities. Thus we find that though they taught no body of astronomical doctrines, they nevertheless employed a rather extended knowledge of the positions and motions of the sun, the moon and of a number of reference stars. They were practicalists and empiricists and their knowledge was empirical. They employed a tacit knowledge of many astronomical truths but they do not seem to have definitely enunciated these truths as elements of any body of doctrines, or teachings.

The Chaldaeans of Babylon were also sun- and moon-worshippers but they were much more interested in the moon than were the Egyptians. The Babylonians devoted great attention to making and recording observations and some measurements on the moon in general and to the study of lunar and solar eclipses in particular. To a slight extent they also reflected upon and drew conclusions from their measurements. To them for example, we owe the remarkable discovery of the eclipse period called the **Saros.** This interval of 6585 days, or 18 years and 10 or 11 days is a

period of recurrence of eclipses of nearly the same characteristics, or types.

The Babylonians also fitted a geometrical progression to the relative sizes of the illuminated portions of the lunar disc from day to day from new moon to the first half-phase, then an arithmetical progression to the relative sizes of the bright portions of the disc from day to day from first half to full phase, and finally, they applied these progressions in reverse order to the daily lunar phases during the last half of the month. This amounts to discovering a mathematical law of the lunar phases. These studies into the regularities of their observed data were the very beginnings of scientific astronomy. The Greeks at a much later date, began their real scientific studies of astronomy with these first steps. Thales, the first Greek astonomer, is said to have won his title as "One of The Seven Sages," from having predicted the occurrence of an eclipse at a certain time, the subsequent event having verified his prediction to within an hour or so. He is said to have had a Babylonian eclipse table, so that all he had to do was to look in his table and see when the next eclipse was due to occur, and then subsequently to remain discreetly reticent as to the source of his knowledge. How modern the ancient sages seem when we come really to know them!

The studies just described, of their observed data has won for the Babylonians the high honor of being the originators of scientific astronomy with its objective methods. In the main however, Babylonian astronomy consisted in the regulation of the calendar and it was empirical and practical, though verging in its late stages toward scientific beginnings.

To these same Chaldaeans also belongs the doubtful honor of being the first to develop astrology. This is the false science which professes to ascertain the influence of the stars on human affairs, to predict by celestial observations wars, famines, and pestilences and to discover the fate of individuals from the positions of the stars at their birth. Some form of this quackery has always prevailed in oriental countries. It flourished at times in Greece and Rome, was an important part of mediaeval thought and even at the present day it is not quite extinct. Still it is well to remem-

ber that if the history of astrology is a painful one, affording repulsive examples of human credulity and knavery, the belief in it has been a powerful stimulus to astronomical study.

The Hindus perhaps at as early an age as the Babylonians, were giving such attention to astronomical observations as their religious observances required. They do not seem to have formulated any doctrines of consequence.

According to unverifiable Chinese claims astronomical observations in China and calendars and almanacs based on them antedate by far the concern for such matters in any other country. This may or may not be a justifiable claim. Certain it is that Chinese influence has never been of consequence to occidental astronomy.

We have now completed the roster of pre-Grecian culture nations whose astronomical records and influences have come down to us to a degree and of a character sufficient to prove of significance to the progress of astronomical thought. Having thus sketched the outlines of astronomical activity down to the period of beginning systematic cultural activities and having pointed out that astronomical methods and recorded findings were practical and empirical in character, let us note what influence the speculative and philosophic Greek exerted on the trend of progress.

Grecian Astronomy

About 600 B. C. Thales opened the first of the six great Greek philosophical schools. His school was subsequently known as the Ionic School. It was located at Miletus on the island of Samos, lying just off the west coast of Asia Minor in the Aegan Sea. Thales and his school acquired quite as high a repute in mathematics and astronomy as in philosophy. The teachings of Thales and his successors Philolaus, Anaxagoras, Aristotle, Eudoxus and Apollonius were little more than ingenious speculations, opinions and subjective theorizings. Such mental operations had met with great success in philosophy and mathematics, both of them being fields of abstract and subjective thought, and the same intellectual processes were deemed necessarily appropriate to astronomy also.

The worst mistake of these great abstract thinkers was that they did not regard observational data as of any con-

sequence to their theorizings. Faith in the efficiency of purely reflective thinking had gone so far that after Aristotle's invention of the syllogism, the philosophical attitude toward truth was: "if the facts do not agree with the theory, so much the worse for the facts." Thus in one century Greek thought had transformed astronomy from an objective and observational character into a purely speculative and theoretical study. This furnishes us the *first great turning point* in the route of astronomical progress.

But Aristarchus even in the early part of the third century B. C. and Eratosthenes in the second century B. C. are two notable exceptions to the general Greek rationale. They were highly objective, experimental and for their day scientific, in their labors. But the genius of these two exceptional thinkers was not commanding in their day, and their influence on astronomical thought and method was epoch-modifying but hardly epoch-making. During the whole period from 600 B. C. to 150 B. C., Greek astronomical activity was engaged chiefly in assimilating and organizing the Egyptian and Babylonian inheritances. Astronomcal leaders generally were quite content to accept the observational findings of the ancient workers as bases for their own speculations. Aristarchus and Eratosthenes however deserve credit for the conversion of Greek *philosophically* speculative into *mathematically* speculative astronomy, which forms the *second significant turn* in our great highway. The turn began about 300 B. C.

Previous to the epoch of Greek activity the world had little notion of a recourse to speculative thinking and abstract reasoning as sources of truth and little or no faith was had in such recourse. It was indeed Greek speculative thought that chrystallized for the world the idea of the worth of truth for its own sake. Recorded experience, such as was thought to be helpful in keeping alive and in guiding life's necessary routine, pragmatic findings perhaps, was about as close as pre-Grecian sages ever came to a conception of truth. Greek speculative thinking created and left to the world the race-ennobling ideal of "truth for truth's sake" as the worthiest of all goals of human endeavor. It was Greek speculative philosophy that first effectively taught the world that correct facts are worthy of permanent

record simply because they are a part of truth. In getting this supreme lesson into the mind of man no class of facts has ever been so impressive as astronomical facts. Greek speculative method has passed away, but the Greek motivating ideal of abstract truth as the supreme objective of human endeavor lives and grows clearer and stronger as the ages go by. Such was the service to humanity of the four and a half century epoch of Thales, Pythagoras, Socrates, Plato, Eudoxus, Aristotle, Euclid, Archimedes and Apollonius.

Hipparchus about 140 B. C., either from a feeling of need for fresh observational check-ups for existing speculative astronomical thinking, or from a native bias for observational work, set about devising more highly refined instruments. After providing himself with the most highly refined instruments the world had known, he undertook a laborious program of star measurements. From his arduous labors of twenty years he compiled the first star catalogue. To reduce his observations for entry in his catalogue lists he needed a calculatory tool for arcs on the celestial sphere that measure distances between stars and none being in existance, he devised a scheme of arcs and chords, which in the hands of Ptolemy subsequently became a *system of trigonometry*. Comparing his own star positions with ancient star places, Hipparchus made many an important discovery of slow star motions. Stimulated by his successes he set about converting the imaginary chrystal spheres of Eudoxus into his own equally and imaginary eccentrics and epicycles for representing the motions of the sun and moon. He thus digested the loose items of antecedent Greek astronomical knowledge into a well-connected body of doctrines and teachings, producing the *third epoch-marking turning point* on the route to a real science of the stars.

No worthy astronomers succeeded Hipparchus for three whole centuries. But about 150 A. D. or a little earlier a kindred astronomical spirit to Hipparchus arose in Claudius Ptolemaeus, commonly referred to as Ptolemy. He made further observations, improved and modernized Hipparchus' star tables, perfected his trigonometry, and elaborated the scheme of eccentrics and epicycles to make them account also for the planetary motions. Ptolemy published his im-

proved scheme in a great treatise of 13 books, known to subsequent science for 1500 years by its Arabic title of "Almagest." This scholarly work completed Hipparchus' turning point and re-directed and straightened the astronomical high road for the world's culture peoples down to Copernicus and Galileo. Hindus, Arabs, Moors, Mediaeval Europeans, Mohammedan, Catholic and Protestant hierarchies all took the Ptolemaic scheme as their unquestioned authority and guide through the fifteen centuries.

Arabian Astronomy

About the only astronomical activity in the world from 800 A. D. to 1350 A. D. was among the Arabs. In the main Arabian astronomy was so intimately associated with their religion and with medicine and astrology as never to have attained the status of an independent science. The influence of their astronomy on the world's progress therefore remains inconsequential, notwithstanding that their names for the most conspicuous stars still belong to the nomenclature of astronomy, and that the Arabs served as a conduit between ancient and mediaeval astronomy when Europe decided to abate warlike activities for some attention to scientific pursuits.

Mediaeval European Astronomy

Borne onward by the traditions of 1500 years, supported by the greatest astronomical names of antiquity, sanctified by concordant scriptural interpretation and hallowed by the highest ecclesiastical authority, the Ptolemaic system seemed impregnable. Compilers of astronomical tables by the middle of the 16th century were finding almost insuperable difficulties in reconciling actual solar, lunar and planetary positions with the positions calculated on the Ptolemaic scheme of eccentrics and epicycles. One of them, King Alphonse X of Spain while supervising the preparation of the Alphonsine Tables, in his discomfiture rather impiously exclaimed: "If I had been present at creation I'd have given some valuable advice." The great Milton talks about the heavens of his day "with cycles and epicycles scribbled o'er." But what earthly power could hope for success in any attempt to swerve the highway of astronomical progress from the well-rutted, traditionally entrenched and eccles-

iastially fortified way of the Ptolemaic system? Let us see!

The only source of truth that was recognized and for many centuries had been recognized as legitimate when Galileo began his scientific labors was *authority,—personal authority.* For the Bible it was a personal God; for religion it was God's vicegerent, the Pope; for philosophy it was Aristotle; for astronomy it was Ptolemy. The authority of human reason, since the Golden Age of Greece, had fallen into discredit and distrust. But at this great focal point of history the world of human thought was beginning to change front.

The minds of men were being cut adrift from age-long cultural moorings and the views of men were being abruptly challenged in the late fifteenth and the early sixteenth centuries to a degree that has hardly been equalled in history. Witness the thought-awakening events of this epoch:

1450, Greek manuscripts were being recovered from original sources, printing was invented, also gun powder.

1453, Constantinople surrendered to the Turks.

1492, America was discovered.

1517, Luther nailed his 95 theses to the door of Wittenberg church.

1521, Diet of Worms adjudged Luther guilty of heresy.

1522, Magellan circumnavigated the globe.

1535, Copernican system was promulgated.

Think of the effect these world-shaking events must have had upon their day and generation. The pulse and pace of human thought was quickened; minds became clearer, less servile and more independent. Astronomy and religion, handmaids through the ages, each furnished an arena on which a life and death contest between ancient error and new truth fought to a decision, the former in the Copernican-Ptolemaic encounter and the latter in the great Reformation of Luther.

What Copernicus actually did in his classic *"De Revolutionibus"* was to take up certain floating ideas which were extremely vague, never having been worked out systematically, to base on them certain definite fundamental principles, and from these principles to develop mathematically an astronomical system which he showed to be at least as capable of explaining the celestical motions as any existing

variety of the Ptolemaic system.

Through a little handwritten tract, *The Commentariolanus*, never published and intended only for circulation among Copernicus' friends, the chief features of the new system had become pretty well known by 1533. In 1539 Copernicus entrusted his enthusiastic young friend Rheticus of The University of Wittenberg with the final preparation for the printer of his complete work. Not being able to finish his task Rheticus entrusted the last stages to Osiander, a Lutheran preacher interested in astronomy, who, becoming alarmed at the probable furore it would arouse, changed the title and wrote a misleading and futile preface from which he omitted his signature. The complete work, with Osiander's title and preface, was published in 1543 and a copy of it was placed in the hands of Copernicus on the day of his death (May 24, 1543), and after his failing powers were too far spent to realize what was happening. No disturbances growing out of Copernican heresies were destined to annoy the piece of mind of the great author. Galileo however was not so highly favored later by the grim messenger.

It was fully seventy years after the death of the author before the great work of Copernicus began to arouse sentiments of hostility. In 1610 Galileo in Padua began showing how his observations with his newly devised telescope confirmed and verified Copernican theories both in general and in detail and confuted the various existing forms of the Ptolemaic system, including the specially devised system of Tycho Brahe. Galileo's discovery and interpretation of the moon's features and phases, of Jupiter's satellites, of Venus' phases and of sunspots, portions of which under pressure of the Roman Inquisition he recanted, added to the observations of Tycho, and Kepler's interpretation of them, together with Kepler's own discoveries, soon settled the plan of the solar system adversely to both the Ptolemaic and the Tychonic theories and favorably to the Copernican hypothesis, converting it into the Copernican Theory. *The fourth turning point* was thus reached about 1625 when Ptolemaic astronomy with its accompanying oriental astrology were diverted into the scientifically experimental and theoretical astronomy of Renaissance Europe. The major

human service at this turn in events was the powerful aid rendered in dispelling the haze of scholasticism.

Newtonian Astronomy

With the subsequent path-finding labors of Kepler and of Newton, astronomy was divorced finally from astrology and the science of the stars was turned into gravitational and theoretical astronomy and cast into the general modern mould. Newton thus brought about *the fifth turn* in the road and since his services such advanced strides have taken place as were never known during the long 1,500 years of Ptolemaic dominance. What an out-standing example of the fact that error, even when excellently systematized, hallowed as truth by the highest established authorities both sacred and secular, and buttressed by century-old tradition, does not prove fruitful to progress, either human or scientific! Disagreement with the facts overthrew the time-honored system of Ptolemy, and agreement with the facts established the system of Copernicus. This is a lesson of history by which modern thought has not been slow to profit. Astronomy has exercised most faithful and persistent leadership along the route of many turns from the brave days of old Aristotle's "If the facts do not agree with the theory, so much the worse for the facts"!

Herschelian Astronomy

Through the labors of the great William Herschel beginning in 1774 the astronomical route took *a sixth turn,* this time back to observational and practical astronomy. Perhaps it would be truer to fact to speak of the change in the route at this epoch as a broadening to a four-lane highway of observational, descriptive, calculatory and gravitational astronomy. No aspects of Newtonian astronomy have ever been discontinued or neglected, but such aspects have actually stimulated the advances and extensions that have since come into being.

Having answered the *how* of the solar system, the *why* of it became a question of absorbing interest. A noble attempt to formulate a theory of the origin of the solar system was made first by Swedenborg, then by Kant and then by the great Frenchman Laplace, who from being the modernizer and extender of Newton's theories has been called the

French Newton. In 1796 he published his historic *Nebular Hypothesis*. This hypothesis rapidly won its way to dominance in cosmic theorizings, and held its place without a disputant until some 50 years ago it was challenged by Lockyer's Meteoric Hypothesis and about 30 years ago it was pretty completely dislodged by the Planetessimal Hypothesis, which is rapidly claiming the field.

Astrophysical Astronomy

About 1860 *the seventh turn* in the astronomical route was toward Astrophysics, which by the application of principles of physics and chemistry, inquires into the kinds and the constitution of the matter composing the celestial bodies, weighing and measuring them, etc. Almost every department and aspect of astronomy is being pursued today with an energy and a success never before equalled.

Conclusion

The latest turn of the great highway is toward the appropriation of the pattern of the solar system as a type for the constitution of the atom, and the great Einstein is so ambitious for scientific unification as to be hopeful of proving at no distant day that electricity, magnetism, light and gravitation are only different manifestations of a single underlying force, that fundamentally there is no such thing as matter, but only force. When he or some one else has done this and then gone on and proved, as Einstein thinks he is on the eve of doing, that the only reality in existence is neither matter nor force, but just space, then truly we shall have closed another important chapter of scientific theorizing.

Summary

Summarizing the narrative of the long route we have been tracing with reference to the eight significant turns of the great highway of astronomical progress, we have the following:

The first turn about 600 B. C. from pre-Greek empirical and practical astronomy to Greek speculative and philosophical astronomy.

The second turn about 400 B. C. from philosophically speculative to mathematically speculative astronomy.

The third turn about 150 B. C. from mathematically spec-

ulative to the observationally speculative astronomy of the Ptolemaic system.

The fourth turn about 1625 A. D. from Ptolemaic astronomy to the scientifically experimental and theoretical astronomy of Renaissance Europe,

The fifth turn about 1687 from Renaissance astronomy to Newton's gravitational and theoretical astronomy,

The sixth turn starting about 1774 from Newtonian astronomy to the observational, practical and theoretical astronomy of the first half of the 19th century,

The seventh turn about 1860 toward astrophysics, which by the application of principles of physics and chemistry, investigates the constitution and kinds of matter composing the celestial bodies, weighs and measures them, etc.

The eighth turn is toward the appropriation of the model of the solar system as a type for the mechanical explanation of the constitution of the atom.

The long starry way with its numerous turns and windings in recognition of new increments to the world's truth from age to age, runs like a golden strand through the pattern of occidental scientific culture, giving theme and motif to most of what we call western civilization. The vistas from vantage points along the way afford to the student an enlargement of mind and a grandeur of soul that make of the sublimest of the sciences a veritable quickener of devotion!

GEOGRAPHIC NEWS BULLETINS.

The National Geographic Society's weekly Bulletins for teachers —the Geographic News Bulletins—will be issued again this year, beginning in early October. Teachers who wish this Bulletin service should send their applications to The Society's headquarters in Washington, D. C., as early as possible.

The issuance of these Bulletins is a service—not conducted for financial profit—to disseminate information of boundary changes, geographic developments, and world progress in other lands. The Bulletins are issued weekly, for thirty weeks of the school year. They embody the pertinent facts for classroom use from the rich stream of geographic information that pours into The Society's office, and they are illustrated from the wealth of geographic photographs in The Society's pictorial library. Five Bulletins, with their accompanying illustrations and maps, go to teachers weekly. A request for the Bulletins should be accompanied by twenty-five cents to cover the mailing costs for the thirty weeks.

SQUARE ROOT IN EIGHTH GRADE ARITHMETIC AND IN NINTH GRADE ALGEBRA.

BY EDITH L. MOSSMAN,

Garfield Junior High School, Berkeley, Calif.

When an eighth grade girl, it disturbed me greatly that the teacher would not—or could not—tell me *why* we should do thus and so in extracting the square root of a number. It seemed impossible to find out the reasons for myself, and in this case, neither one of my parents could, as usual, clear up the perplexity for me.

My first year of teaching did not require any class-room presentation of this subject, but one of the pupils brought a problem which his father wished me to solve. It involved square root and I had utterly forgotten the process. Fortunately, the solution was not required until the next day, so there was time to look up the rule in the text-book, foliow it closely but "blindly" as in school girl days—and see the correct answer "pop out."

The next summer I appealed to the late Dr. David Felmley of the Illinois State Normal University for the raison d'être. He gave it to me in perfect clearness.

Three or four years later another father asked me for the solution of a problem involving square root. There had been no occasion for me to think of this subject at all in the meanwhile, but great was my joy at finding it unnecessary to look up the rule in a text-book this time. The process was quite readily recalled.

This strengthened my growing conviction on two points: First, one will remember much longer and much more clearly a mathematical process for which he has seen the reason, than one in which a rule or direction has been followed without knowing the "why," even though there has been far more drill in the latter case. Second, regardless of length of time remembered, either child or adult has a mental experience that in itself is of much more value if he sees plainly *why* each step is taken, than if he *"unthinkingly"* follows directions that cause the *right answer* to appear on his paper.

Psychologists have discarded much of the old transfer of learning theory but they still observe more than a little transfer of habit.

For the average child, many, perhaps nearly all of the actual mathematical facts acquired will drop away through lack of use. If these facts have been acquired through memory and imitation only, there has certainly been a tragic waste of time to say the least. But if his courses in arithmetic, algebra, and geometry have been such as give him valuable mental experience and growth—such as to strengthen *habits* valuable in all walks of life to all sorts of people, then the time is far from wasted even though the mathematical facts in the larger part are forgotten.

It has many times been my privilege to teach square root to a class of boys and girls. Each time I have thought over the plan of presentation and each time improved it a bit here or there. Of course, a progressive, wide-awake, "teachable" teacher learns more from her class-room experiences than from any other one source. She watches the pupils alertly, sees how they react to this plan and that —listens intently to learn all she can from them.

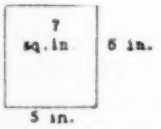
Last spring gave me the joy of seeing definitely better results than ever before in this subject, both in arithmetic and in algebra—results, indeed, so happy that it is worth while to outline the method of procedure.

First Day

Questions, oral problems, discussion to make plain to *all* the meaning of:

(1) The square of a number,

$5^2 = ?$ $5 \times 5 = ?$



(2) The square root of a number.

$\sqrt{25} = ?$

Distinguish between $\sqrt{25}$ and factors of 25

(1) What is the square root of 25? Ans. 5

(2) What are the factors of 25? Ans. 5×5

Three definitions of square root:

(1) The square root of a number is that number which multiplied by itself gives the original number.

(2) The square root of a number is *one* of the *two equal* factors of the number.

(3) The square root of a number is the length of a square whose area the given number is.

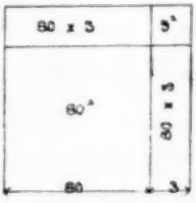
Assignment: Very simple problems in stating (a) squares and (b) square roots of small numbers.

SECOND DAY

Statement of the astonishing fact that today the pupils will be asked to do something by a rather *long* method when they already know a much shorter way in which to do it. Discussion follows as to what might possibly be the reason for a teacher asking what appears on the surface to be so unreasonable.

(The boys and girls give most gratifying answers. In no case was it necessary for me to say that the reasoning used here would be needed to make plain the steps in some work coming later. Always one of the pupils offered that idea to the class.)

Problem: $83^2 = ?$



$83 = 8 \text{ tens} + 3 \text{ units}$

or $80 + 3$

$80^2 = 6400$ (Large square)

$2(80 \times 3) = 480$ (2 Rectangles)

$3^2 = 9$ (Little square)

6889 Area. Ans.

Check:

(Find area in your own old simple way of multiplying)

$$\begin{array}{r} 83 \\ 83 \\ \hline 249 \\ 664 \\ \hline 6889 \end{array}$$ O. K.

Assignment: Several, perhaps ten, similar problems in two place numbers. "Show diagram and label parts of answer always as in given model."

THIRD DAY

"After today's work has been corrected, keep your papers carefully. We shall use them again in class tomorrow. But today, we'll collect some tools that will be needed

tomorrow in order to make finding the square roots of large numbers easy."

Squares of numbers from 1 through 9.

$1^2 = 1$

$2^2 = 4$

etc.

$9^2 = 81$

"If there are any who cannot already do so, they will be wise to become able by tomorrow to give those few squares very readily."

"If you look in any arithmetic text, you will find the first part of the rule for extracting the square root of a number says something like this: 'Mark the member off into periods of two places each.' Let's see *why*."

(Discussion barely hinted at here.)

$1^2 = 1$ Square of smallest 1 place number.

$9^2 = 81$ Square of largest 1 place number.

$10^2 = 100$ Square of smallest 2 place number.

$99^2 = 9801$ Square of largest 2 place number.

$100^2 = 10{,}000$ Square of smallest 3 place number.

$999^2 = 998{,}001$ Square of largest 3 place number.

Therefore:

Square of every 1 place number = 1 or 2 place number

Square of every 2 place number = 3 or 4 place number

Square of every 3 place number = 5 or 6 place number

etc.

Conversely:

Square root of every 1 or 2 place number = 1 place number

Square root of every 3 or 4 place number = 2 place number

Square root of every 5 or 6 place number = 3 place number

$\sqrt{4} = 2$ $\qquad$ $\begin{array}{r} \text{sign} \\ 2 \\ \sqrt{4} \end{array}$

$\sqrt{64} = 8$ — units: 8; $\sqrt{64}$

$\sqrt{324} = 18$ — tens: 1, units: 8; $\sqrt{3\ 24}$

$\sqrt{4,624} = 68$ — tens: 6, units: 8; $\sqrt{46\ 24}$

$\sqrt{13,924} = 118$ — hundreds: 1, tens: 1, units: 8; $\sqrt{1\ 39\ 24}$

$\sqrt{394,384} = 628$ — hundreds: 6, tens: 2, units: 8; $\sqrt{39\ 43\ 84}$

(After larger whole numbers have been used, explanation must be given as to why the rule says, "Beginning at the decimal point," i. e., *Not* 46 3.5 *but* 4 63. 50)

Assignment: (1) The list of small squares at the tip of the tongue.

(2) Careful thinking over of *how many* figures in the square root of a given number, and what the first figure will be.

(3) Five more two place numbers whose squares are to be found as in the problem brought today.

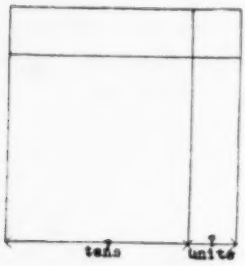
FOURTH DAY

"Yesterday, by a long method, you found the square of 83 to be 6889. Today, let us take 6889 and find its square root, pretending that we do not already know it is 83."

Problem: $\sqrt{6889} = ?$

"What is to be done first?"

68 89

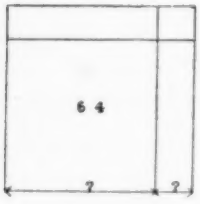


"How many figures will there be in the root?"

$$\begin{array}{r} \overset{\text{tens}}{?}\ \overset{\text{units}}{?} \\ \sqrt{68\ 89} \end{array}$$

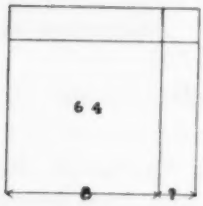
"Now think of the list of small squares you know. What is the *largest* perfect square in that left-hand period, 68?"

$$\begin{array}{r} \overset{\text{tens}}{\ }\ \overset{\text{units}}{\ } \\ \sqrt{68\ 89} \\ \underline{64} \end{array}$$



"If that big square is 64, how long must its side be?"

$$\begin{array}{r} \overset{\text{tens}}{8}\ \overset{\text{units}}{\ } \\ \sqrt{68\ 89} \\ \underline{64} \quad \text{Area large square} \\ 4\ 89 \quad \text{Area 2 rect's and little square} \end{array}$$

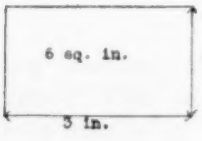


"What is left in the original square that we have not yet used?"

"What do we know about those two rectangles and the little square?"

[(1) Area=489 (2) Length of 2 rectangles=160]

"What do we want to know about them?" [Width]



"If we know an area and length, what do we do to get the width?"

$$\begin{array}{r|l} & \text{? in. width} \\ \hline \text{3 in. length} & \text{6 sq. in. area} \end{array}$$

The rule says: "Take twice the root already found with a cipher annexed, as a trial divisor."

Why *twice* the root?

(Length of two rectangles)

Why twice the *root already found?*

(The root already found=length of large square= *also length of rectangle*)

Why annex a cipher?

(8 tens=80 units. We are now hunting for the units' figure in the root.)

Why call it a *trial* divisor?

(Not quite *all* the length. 'Tis the length of 2 rectangles. Length of little square not yet known.)

$$\begin{array}{r|l} & \overset{\text{tens}}{8}\ \overset{\text{units}}{} \\ & \sqrt{68\ 89} \\ & 64 \\ \hline \text{Trial divisor or Length of 2 rect's. } 2\times 80=160 & 4\ 89 \text{ area of 2 rect's } \textit{and} \text{ little square} \end{array}$$

How many times is 160 contained in 489?

Do *four* things with that 3.

(1) Put it in the answer.

(2) Add it to the trial divisor. Why?

(To get *total length* of 2 rectangles and little square.)

(3) Multiply that total length by this same number. Why?

(To get the area of the 2 rectangles and little square—to see if we have the correct figure for units' place.)

(4) Show it on the diagram: (This is done by inserting the correct figures below the question marks in the diagrams).

$$\begin{array}{r|l} & \overset{\text{tens}}{8}\ \overset{\text{units}}{3} \\ & \sqrt{68\ 89} \\ & 64 \\ \hline \text{Length of 2 rectangles } 160 & 4\ 89 \text{ area of 2 rect's and little square} \\ \text{Length of little square } +3 & \\ \hline \text{Total length } 163 & \\ \text{Width } \times 3 & \\ \hline \text{Area } 489 & \end{array}$$

Check

$$\begin{array}{r} 83 \\ 83 \\ \hline 249 \\ 664 \\ \hline 6889 \end{array}$$ O. K.

"Now let us take the next square you found and extract its square root." (If time take a third also.)

Assignment: Use similarly the other answers found on yesterday's paper.

FIFTH DAY

Assignment: Take the five squares found yesterday. Extract the square root of each.

Also, take five from the book, whose square roots you do not already know.

SIXTH DAY

Three-place and four-place roots.

The diagrams for these require two additional rectangles and a small square for each additional place in the root.

LATER DAYS

(1) Numbers *not* perfect squares. These diagrams show an unused part of the square which is shown by dotted lines and represents the remainder. The width of the unused part is represented by the plus sign in the root.

(2) One or more zeros in the root. After discovering by computation that a zero occurs in the root the proper lines in the diagram may be crossed out.

(3) Decimals.

(a)
$$\begin{array}{r} {\scriptstyle \text{tens}}\ 2\ {\scriptstyle \text{units}}\ 5 \\ \sqrt{6\ 25} \end{array}$$

(b)
$$\begin{array}{r} {\scriptstyle \text{units}}\ 2.\ {\scriptstyle \text{tenths}}\ 5 \\ \sqrt{6.25} \end{array}$$

(c)
$$\begin{array}{r} {\scriptstyle \text{tenths}}\ .2\ {\scriptstyle \text{hundredths}}\ 5 \\ \sqrt{.06\ 25} \end{array}$$

But

(d)
$$\begin{array}{r} {\scriptstyle \text{units}}\ 7\ {\scriptstyle \text{tenths}}\ .9+ \\ \sqrt{62\ .50} \\ 49 \\ \hline 1350 \\ 1341 \\ \hline 9 \end{array}$$

$$\begin{array}{r|l} 2\times 70=140 & \\ +9 & \\ \hline 149 & \\ \times 9 & \\ \hline 1341 & \end{array}$$

Applied to algebra the method proved good. The test given to two classes totalling about 60 pupils, resulted in papers more than half of which were perfect—all the rest were "B's" except three—and one of these three was from a pupil who had been absent.

The work was briefly presented in arithmetic first, much to the delight of most of the class, several declaring their joy in *understanding* a process that in 8th grade had been "Greek" to them.

The next day trinomials involving no negatives were given. Then followed polynomials of more terms, also quantities not perfect squares.

Before giving problems involving negatives, there was a review discussion of the two uses of the minus sign:

(1) Sign of operation, i. e., something to do.

(2) Sign of kind of quantity. Then in using the diagram, we used the sign to denote *kind* of quantity, not to signify "take away."

In the arithmetic class each row had a monitor who collected the daily papers and kept a record of credits earned on those papers. In this work, credits were given on each problem as follows:

(1) 1 for estimate
(2) 1 for drawing
(3) 1 for solution
(4) 1 for check

Fewer problems each day were given than had been customary, but the sort of careful, "all-around" thinking experienced by each child in earning those four credits on each problem resulted in a truly remarkable record on the final written test. We felt as if we had all been together at a wonderful party, the boys and girls were so "bubbling over" with happiness.

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60 CENTS BUYS ONE DAY'S EDUCATION FOR CITY CHILD.

Sixty cents, the price of a pound of candy or a single golf ball, buys one day's education for a child in the average city public school.

This fact is disclosed by the figures presented in "Per Capita Costs in City Schools," a biennial study prepared by the Office of Education, Department of the Interior. Statistics from a representative group of American cities show that the total average annual cost per child for teachers' services for nine months, for heat, janitor service, and, in most instances, school supplies, books and library facilities, is $108.87.

Since instruction costs, which include teachers' salaries, books, and the library, make up three-fourths of total school costs, the city child gets the service of trained teachers and useful textbooks for approximately 47 cents per day or 8 cents per hour.

NOTEBOOK WORK IN BIOLOGY AND TRAINING IN THE SCIENTIFIC METHOD OF THINKING

By Amer M. Ballew,

Austin High School, Chicago, Ill.

A recent study[1] of biology notebook work by Don O. Baird raises several pertinent questions of interest to teachers of high school biology. It will be the purpose of this article to discuss some of his findings in the light of modern teaching practice.

In a questionnaire study Baird asked teachers of biology to rank the notebook objectives in the order of their importance. The following objectives were listed:

1. Development of power of observation.
2. To furnish training in the scientific method of thinking.
3. To clear up false inferences.
4. To fix biologic principles.
5. To develop ideas.
6. To establish worth of biologic principles.
7. To develop skill in biologic drawings.
8. To arouse interest in biology.
9. To develop power in solving biologic problems.
10. To provide techniques for solving science problems.
11. As an aid to memory.
12. To preserve facts for future reference and review.
13. To enable pupils to meet college entrance examinations.
14. To develop habits of honesty.
15. To develop habits of neatness.
16. To offer opportunities for teachers to learn extent of pupil vocabulary.
17. To furnish valuable training for subsequent science work.
18. To furnish opportunity for exercise of initiative.

The development of power of observation received first rank and to furnish training in the scientific method of thinking received second rank. There would seem to be considerable overlapping between these two objectives.

It was found by Baird that the average notebook contained a total of 9,401 words and consisted of 46 units of written matter.

In the case of drawings, the average notebook contained 64 drawings and the range was from 24 to 154. Most of the drawings were of the non-analytical type rather than analytical and there was evidence to show that many of the drawings were copied entirely from textbooks.

In his summary Baird makes the following generalizations:

The notebook work has followed the traditional lines of the older

[1]Baird, Don O. A study of Biology Notebook Work in New York State Teachers College Contributions to Education, No. 400. New York: Teachers College, Columbia University, 1929.

sciences—chemistry, physics, botany, zoology, and human physiology. Much of it appears to be too informal and does not seem to have kept pace with the rapidly changing needs of society.

The major emphasis is upon plant and animal structure.

The laboratory work should be more related to the life of the pupil.

A few major projects in biology laboratory work planned by the teacher for a year's course would result in activities more valuable to a pupil than thirty or more isolated experiments and demonstrations.

The work of high school biology should motivate the lives and activities of the pupils in purposeful activity rather than be a course in a prescribed task of writing so many units of work in a notebook.

This excellent study by Baird was made in the state of New York. However, there is little reason to believe that his findings are not typical for any part of the country.

Practically all students of the high school curriculum agree that one of the main objectives of science instruction is training in the scientific method of thinking. The steps involved in this process are: the statement of a definite problem, gathering facts relative to the problem, an analysis of the importance of the facts and the reaching of a definite conclusion in regard to the original problem. The importance of correct thinking habits is realized when one considers the need of each individual of society to be able to think clearly along matters of a personal and civic nature. Science lends itself particularly well to the development of this type of thinking.

Are we really giving the high school student of biology suitable training in the scientific method of thinking? The answer cannot be a dogmatic yes or no. Probably we are falling far short of our possibilities. The practical benefits of science are of such common knowledge today that many are inclined to think that there is some peculiar intangible property about the study of science which automatically develops proper thinking habits. The exploding of the theory of formal discipline has shown that a mere study of science will not secure our objective. Modern psychological research has revealed that if we wish to put across certain definite objectives in our instruction, those objectives must be made concrete and made to function in the everyday life of the student. Is it not at this point that much of our science instruction falls short of achieving its real purpose?

Training in the scientific method of thinking can hardly be attained by a study of the textbook only. For this

reason the laboratory was developed because of its peculiar adaptability to the development of orderly thinking habits.

The notebook in biology has long been used as an aid in laboratory instruction. It was only natural that in the beginning, biology teachers should adopt the formal methods of the college and university and place the emphasis upon plant and animal structure with the numerous detailed drawings associated with that type of work. It is only of recent years that we have begun to analyze our methods of instruction and to build our curriculum around the child as the focal point.

Baird has given us a good picture of modern high school biology notebook work. If we were to visit a typical laboratory class in biology what would we find them doing? Many of the students would be spending much of their time making detailed descriptive drawings of preserved specimens. Some would be copying the drawings from their textbooks or from neighbors. When the drawings were finished they would proceed to "write up" the experiment. This would consist of answering questions about the specimens studied. This writing procedure would occupy the rest of the laboratory period and often run over into the next. Many of the students would copy the answers which their neighbors had given to the various questions. If it were near the end of the biology course, an examination of the notebooks would disclose the great amount of written work performed by the student.

Is this type of laboratory procedure developing in the student orderly thinking habits which we call the scientific method? As we analyze the steps in this method we are forced to answer largely in the negative.

How may high school teachers of biology use the laboratory notebook to aid in developing proper thinking habits? We need to recognize at this point the conditions under which the average teacher has to work: large classes and many extra duties outside the classroom. Too many of our education theories, while possessing merit, are practical only in the most favorable environment such as that of the experimental school.

One important step in the right direction would be to

eliminate from the notebook those items which do not give direct training in effective thinking. Experimental studies have shown that descriptive drawings do not adequately develop accurate observations. Analytical drawings have been shown to be a valuable aid in developing scientific observation.

We have often proceeded under the assumption that the more encyclopedic the notebook the better we had performed our work as science teachers. This conception has arisen, perhaps, because of the tendency to exhibit notebooks on visiting days and the obsolete idea of the student using the notebook for college entrance. We need to recognize that the only justification for a laboratory notebook lies in the fact that it is an aid to the student while he is in school, in developing orderly methods of thinking and will have little value once he has completed his high school work.

It is impractical to provide a great number of original observations and problems for the large science classes which are typical today. In this connection, it would seem, lies the justification for considerable demonstration work on the part of the teacher. The skillful teacher by the use of charts, models and other demonstration materials, can give the class training in the scientific method of thinking. The attention of the class is focused upon the demonstration and the students may be lead to a definite conclusion by a series of well worded questions. It is entirely possible for the teacher by the wise use of questions, to leave the problem in such a way that the students may show by their notes whether they have grasped the steps in the solution of the problem.

Suppose the problem for consideration is: Do Seeds Require Oxygen for Germination? This may be performed by a group of students or by the teacher. At the proper time two flasks are shown to the class. Both flasks have damp sawdust in the bottom and soaked pea seeds placed upon the sawdust. One flask was stoppered while the other was left open. The student, keeping the original problem

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[2]Ayer, Fred C. The Psychology of Drawing. Baltimore: Warwick & York, Inc., 1916.

[3]Ballew, Amer M. A Comparative Study of the Effectiveness of Laboratory Exercises in High School Zoology With and Without Drawings. School Review. XXXVI (April, 1928) 284-295.

in mind, makes observations towards the solution of that problem.

Instead of having the student write an essay describing in detail all of the steps in the experiment, two simple analytical diagrams of the flasks will show at once whether he has made accurate observations. There is no pedagogical reason why laboratory notes may not often consist largely of analytical diagrams showing the results of carefully controlled experiments. The statement of the problem may be given above the diagrams and the conclusion below. If the teacher is careful to see that the work is not copied from other students and is performed only in the laboratory, procedure of this kind will give training in thinking to a logical conclusion. The amount of time taken for the notes is small leaving more time for laboratory observations which after all is the chief function of the laboratory. A decided advantage to the teacher is the comparative ease with which the work may be checked during the laboratory period and new observations made by the students, if necessary, while the problem is fresh in their minds. It is quite probable that a few carefully planned exercises of this type would do more to develop correct thinking habits than many of the essay type exercises.

We have stressed too much, I believe, the informational side of notebooks and not enough the functional side. We have often thought of the notebook as the end in itself rather than a means to an end: the development of certain desired habits in the thinking process of the student.

A NEW DEAN OF MEDICAL SCIENCES AT MINNESOTA UNIVERSITY

Dr. Richard E. Scammon, during the last academic year dean of medical and biological sciences at the University of Chicago, has returned to the University of Minnesota to fill the newly created post of dean of medical sciences. Dr. Scammon was professor of anatomy at the University of Minnesota prior to his going to Chicago in the fall of 1930. He has done much research work in comparative embryology and the growth and physical development of children, and is the author of several books on these subjects. In his new position he will be especially charged with the stimulation of research in medical science and related fields that requires the cooperation of the various colleges of the University.

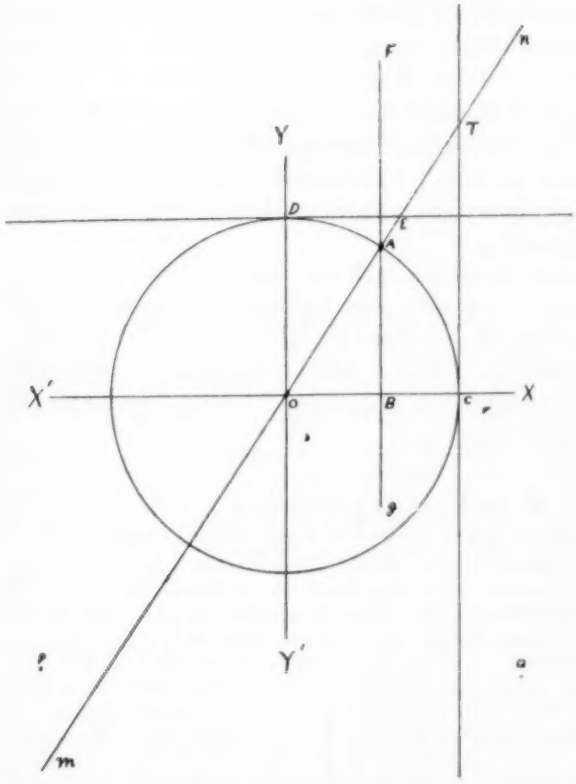
VISUALIZING TRIGONOMETRY

By L. E. McAllister,
Shorter College, Rome, Ga.

Introduction

The author has found in teaching trigonometry that some students have trouble in visualizing such things as: (1) the values of the trigonometric functions from 0° to 360°, (2) the + and − signs before the functions for angles greater than 90°, and (3) the Pythagorean formulae. The device shown in the figure is an attempt made by the author to make this visualization easier.

Construction



A piece of white cardboard 1 ft. by 2 ft. is tacked to a flat wooden board that may be hung on the wall. The following lines are drawn heavily on the cardboard: (1) a circle of 4 inch radius, (2) the X-axis (xx′), (3) the Y-axis (yy′), (4) a tangent to the circle at C (full length of paper), and (5) a tangent to the circle at D. The line mn is a heavy stiff wire 2 ft. long, ⅛ inch in diameter, flattened and holes bored at O and A, and a nail driven through at O so that it can easily rotate around that point. The line Fg is also a heavy wire flattened and a hole bored at A and

fastened to the wire mn by a small loosely fitting rivet. Ag must be longer than AF so that the wire will always be in a vertical position. AF must be longer than the radius of the circle. Nails may be driven at some points P and Q to hold the wire mn in one fixed position in each quadrant.

THEORY

If the radius of the circle is considered as unity, then the values of the six trigonometric functions are represented by the following lines: (1) Sine = BA. If B is between A and F, the sine is −. (2) Cosine = OB, If B is to the left of O, the cosine is −. (3) Tangent = CT. If T is below C, the tangent is −. (4) Cotangent = DE. If E is to the left of D, the cotangent is −. (5) Secant = OT. If T is between O and m, the secant is −. (6) Cosecant = OE. If E is between O and m, the cosecant is −.

USE

By simply rotating the wire mn around the point O, the sine and cosine may be seen to pass through all their values as the angle passes from 0° to 360°. The successive values of the other four functions are shown except where they become large and run off the cardboard.

The Pythagorean formulae such as: $\sin^2\theta+\cos^2\theta=1$, $\tan^2\theta+1=\sec^2\theta$, and $\cot^2\theta+1=\csc^2\theta$ are obtained by applying the Pythagorean formula of geometry to the triangles OAB, OTC, and ODE respectively. Many other trigonometric relations may also be obtained from this device. They will probably be obvious to any teacher using it.

PLATINUM ELECTRODES.

By G. T. FRANKLIN, *Lane Technical High School, Chicago, Ill.*

A method of constructing a simple conductivity cell suitable for high school experiments was described in SCHOOL SCIENCE AND MATHEMATICS, November, 1930. The electrodes of this cell consist of short platinum wires sealed into a glass tube with ends protruding inside and outside. A drop of mercury is inserted in the tube and contact made with copper circuit wires. This method is very handy when it is desired to use connectors of different lengths for various needs. The objection to it is the ease with which one spills out the mercury. Mr. Frank B. Wade, Editor of the Chemistry Section of SCHOOL SCIENCE AND MATHEMATICS, asked the writer this question in connection with the cell: "Did you ever melt a tiny ball of copper on the end of your copper wire and tuck the end of a red hot platinum wire into it, then fuse the platinum wire into the seal at the end of your glass tube?" The writer tried the method and was surprised with the ease with which it could be done by an amateur and has since replaced all of his electrodes involving this type with it.

A SOCIALIZED SCIENCE PROJECT.

By Elizabeth G. Sichler

Jackson Intermediate School, Detroit, Michigan

You send your child to the schoolmaster, but 'tis the school boys who educate him.—Emerson.

The project, it will be remembered, started off as a distinctly individual procedure. It meant an actual manual undertaking, such as growing potatoes, or making something in the shop. As it has been later applied in the schools, it has come to be more of a text-book affair. Nothing can be more fatal to interest in science than making it merely a text-book affair. If science teaching is restricted to book and demonstration, many of its possibilities for the individual pupil are ignored. Let us turn then to a modern method of instruction, adapt it as far as possible to the conditions of a class room and see how it works and whether it seems to have any advantages over the conventional method just criticized.

Reasons for a Socialized Project

We may summarize the reasons for taking up this work as follows:

(1) A desire to compare its results, by test averages and observation with those obtained with the recitation-demonstration method.

(2) A desire to return to the old project method to the extent of making some provision for the pupils to use their hands and skills in a productive project; in other words, to make the course more than mere book study.

(3) A wish to combine in some way individualized and group procedure.

(4) A hope to provide for a parliamentary type of group organization, i. e., for socialized procedure and group control, rather than teacher control.

(5) A strong suspicion that the contract, or job sheets, used the preceding semester, were not the best possible method for an appreciation, discussion subject, such as a junior science course must largely be.

(6) A desire to add to the interest of teaching by this adaptation of the project method—a thing the writer strongly recommends to other teachers when they find themselves going a bit stale.

METHOD

Two X groups were chosen, one of which was to proceed over the same units as the other, but by the socialized project method. The other was to proceed by the usual recitation method. The first class was to have a parliamentary club organization, the other to be largely teacher dominated. From the course of study, guide sheets for the projects were worked out along the lines of a similar project in English, used at the Cass Technical High School. These sheets, presented to the writer by the principal of the school with the words, "I think that you will be interested in these," formed the immediate stimulation for the form given to the guide sheets, which were worked out as follows:

GUIDE SHEETS ON UNITS 9, 10, 11

PART I. GENERAL DIRECTIONS

MATERIALS TO BE SECURED

1. A notebook.
2. Any material needed for individual activity or group project.

PROCEDURE FOR CLASS PRESIDENT

1. Preside over the class.
2. Held group leaders.
3. See that strict order is kept at all times.
4. Lead class in programs, recitations, etc.
5. Help students to decide on their projects.
6. Confer with teacher on any issue which may arise.

PROCEDURE FOR CLASS SECRETARY

1. Keep attendance record.
2. See that all excuses are presented and signed.
3. Take and read "minutes" each day.

PROCEDURE FOR CLASS AS A WHOLE

1. The work will be divided into:
   a. Work-shop days
   b. Program days
   c. Test days
2. On work-shop days we will:
   a. Work on individual activities, or
   b. Work on group projects
   c. Perform experiments
   d. Plan programs
3. On program days we will:
   a. Present the group projects or individual activities. No one will be excused
   b. Each student is to outline the important facts presented and *learn* the *outline*, as this covers the work as a whole
4. On test days there will be:
   a. A review
   b. A short test

PROCEDURE FOR STUDENTS

1. Each group decides by a majority vote whether it will work together on a group project, or work separately on individual activities.

2. After the group has voted, select either a group project or an individual activity from the lists given below, according to what the group has voted for.
3. Secure the teacher's O. K. before starting work. Group leaders should consult the teacher as to the work as it progresses.
4. You are responsible for the information given in the reading under *Reference Books*. Do not spend all of your time working on projects or activities. Spend at least fifteen minutes each work-shop day reading from the references given. This information will be asked for in the test.
5. Each one must present his work on Program Days.
6. On test days each student will review the material which has been covered and prepare himself for a short test on the essentials of the course.

PART II

INDIVIDUAL ACTIVITIES

1. Making a booklet on the subject being studied.
2. Drawing, sketching, painting pictures.
3. Dramatizing the subject.
4. Floor talks on information gained from reading.
5. Carving in soap.
6. Collecting and mounting pictures.
7. Collecting and mounting newspaper articles.
8. Writing stories based on the subject.
9. Writing reports. Bring material to class. Only a very small group may go to the library.
10. Map making.
11. Black-board drawing.
12. Card-board and paper construction.
13. Making posters.
14. Performing experiments.

GROUP PROJECTS

Any group may take *one* of the projects listed. The first sentence, or question, which is underlined, is the general heading for the project. After it are listed questions and suggestions. Do not limit yourselves to them, however. Work up the project as completely as you can. Find out *everything you can* about the subject. Read every reference book. They are listed at the end of each unit.

UNIT 9

How Man Obtains and Uses the Fuel Material of the Earth

Project 1. *A study of coal and coal mining.* How is coal mined and graded? Where are the different coal mines of the country? (Maps.) What products come from coal? Read the References carefully on this subject.

Project 2. *What fuels are prepared by man artificially?* Study the Reference Books for material on oil. Why is it under this heading? How are gasoline and kerosene produced How is gasoline used by motor cars?

Project 3. *The heat value and cost of various fuels.* What determines the heat value of a fuel? Why does coke make a hotter fire than coal Why does soft coal produce more smoke than hard coal? Why does the price of fuels vary in different parts of the country? Find out which fuels are cheapest; which most expensive. Why is wood less used than formerly? What fuels are best for homes, for factories?

Reference Books for Unit 9:

Civic Science in Home and Community, Hunter and Whitman, pp. 123-127.

Early Steps in Science, Webb and Didcoct, pp. 60-62.

UNIT 10

What Devices Man Produces Which Enable Him to Work More Easily

Project 1. This may be called "The Age of Machinery." What are the *chief labor-saving* devices and machines man has developed, and why is each important? This includes factory and home and everything you can find out about labor-saving devices.

Project 2. What is meant by *work* and how is it measured? List some of the kinds of work still done by hand. Collect as many cases as you can in which work is done, such as climbing stairs, pushing an automobile. Discuss questions like the following: Is riding a horse work? Flying an aeroplane Everything you can find out about *work*.

Project 3. *The lever.* This is an extremely important mechanical principle. What machines make use of it? What are the three kinds of levers How is the work done measured by levers? Investigate all the information you can get about levers.

Project 4. *Energy.* The source of energy. The transformation of energy. How electricity, water, steam, and other forms of energy do work. Investigate the subject of energy as thoroughly as you can.

Reference Books on Group Projects for Unit 10:

General Science, Caldwell and Eikenberry, pp. 206, 207, 211-214.
Early Steps in Science, Webb and Didcoct, pp. 86-98.
Civic Science in Home and Community, Hunter and Whitman, pp. 185-196.

UNIT 11

How Man Makes Air, Water and Steam His Servants

Project 1. *How is the force of moving air made to work for us?* Make a study of the uses of the *windmill*, where it is used, how it is constructed. *Air pressure* is also an important subject for this project, as, how men are able to work under water. How does the siphon work?

Project 2. *How is water made to work for us?* Study the ways water power is utilized. Why is the turbine more efficient than the ordinary water wheel? Why is water called "white coal?" Study types of water wheels; also some of the great sources of water in the United States (maps showing great dams, falls).

Project 3. *How does steam work for us?* What is the real source of the energy produced by steam. Study and describe *steam engines.* This project should also work up the *history* of the use of steam. (Robert Fulton and the first steam boat, for example.) What important improvements did Watt make in perfecting the steam engine? How has the development of the locomotive helped the growth of the United States? Study, also, the turbine engine. Why is it used largely in ships and electric power plants? Steam boilers should also be studied; the question of the steam automobile should be taken up by some member of the group.

Reference Books for Unit 11:

Civic Science in Home and Community, Hunter and Whitman, pp. 301-315, 415-419.
Science of Home and Community, Trafton, pp. 227-239.
Early Steps in Science, Webb and Didcoct, pp. 221-232.
General Science, Caldwell and Eikenberry, pp. 206, 207, 211-214.

These guide sheets endeavored to realize the aims enumerated above in the following ways, by:

1. Following a socialized organization.

2. Providing for exchange of reactions and individual cooperation.

3. Providing for individual activities which involved the use of the hands. (Expressional ends.)

4. Unifying the individual work under the subject of the group project and bringing the group projects together under the unit being studied. In this way, it was expected that everyone would understand the particular part they played, as group and as individual, in the class work as a whole.

5. The teacher was enabled, by the minutely mimeographed directions and by the responsibilities undertaken by the class officers (each group had a leader, under the class president) to remain in the background, as general consultant.

The general procedure was, briefly, as follows: After the election of class officers, which were to rotate semi-weekly in order that as many members of the class as possible might have the valuable experience of leadership, the four groups into which the class was divided selected their leaders, who were to be responsible for the carrying out of the project of their particular group. Each group then selected its project from those listed. If there was a conflict, the chairman settled it.

There followed a series of "workshop" days during which each pupil worked on his individual activity and the chairman made out the program which was to be presented at the end of this workshop period. During this time, also, they were expected to do the studying assigned in the refences.

One or more periods were taken up by the "Program," the flowering of the period of preparation. There were booklets, playlets, reports, posters, soap carvings, floor talks, maps, experiments performed, and a number of other by-products of the work which did not emerge from the book-demonstration method class. After each presentation, class and teacher made constructive criticisms of the work.

Next followed our "review" period, in which the more strictly informational side of the work was discussed and evaluated. Each group presented the information in the references bearing upon the subject of the project they had

chosen. This discussion often covered several periods. The teacher entered more largely into this part of the work than any of the other preceding activities. For after all, the teacher must give more than can be obtained from the textbooks alone.

When the review was finished there followed a short new-type test, usually "completion" and "matching," on the work of that unit. The review having organized the work of the unit as a whole, the pupils were expected to know all the information given in the references when it was concluded, by taking notes, asking questions and reading. As No. 4 under "Procedure for Students," states, "You are responsible for the information given in the reading under Reference books." As stated above, time was allowed for this during work days, so that, even though the material was developed as separate projects, the pupils, in the end, obtained the desired information.

RESULTS

A test was given at the end of each unit. The figures are given as a matter of interest, although they are not highly significant. P. T. stands for the preliminary test, given as a teaching guide at the beginning of each unit.

TEST AVERAGES

	1		2		3		4
	P. T.	T.	P. T.	T.	P. T.	T.	Final test
Project class	30	80	22	76	40	78	78
Recitation class	28	84	26	80	30	74	82

These figures are the factual results, average grades. But the factual side was not emphasized in this work. Science consists of facts, to be sure, but it is even more an interpretation and appreciation of facts. That is where the teacher is indispensable. And that is the time-honored aspect of science teaching—understanding and memorization of facts. The methods just described tried to introduce other factors into the class room—self-activity, self-criticism, work with the hands, supplementing facts with imagination, as in pictures and dramatization. These results were not measurable, the means were lacking. But they were distinctly observable. There was added interest and zest, pride in production, mutual help, group cooperation, purposeful activity, an expressional end. There was

not merely a reproductive, but a productive aim. It is the writer's opinion, that had this group continued with this work for a longer period, say a year, these results would have been even more noticeable. The term "habits and attitudes" has been purposely avoided, as direfully vague. In the common sense of the term, however, they were certainly undergoing a development. And if, as is being more and more emphasized, education should train for citizenship and cooperative effort, as well as for factual knowledge, it is certainly worth incorporating into our method. We may say, then, that the enrichment of the course by the introduction of these individual activities, combined with socialized procedure and group production, produced noticeable, if unmeasurable, results.

CONCLUSION

The conclusions which the writer has formed from this study may be thus summarized:

1. This method is more satisfactory with a high group. It is well known that groups of low mentality do not work together so well and are not self-directing. It is doubtful if this would prove satisfactory with a low group.

2. As far as factual mastery is concerned, the old recitation, teacher-dominating method is as satisfactory as the socialized project. This is shown by the test averages.

3. The main values to be derived from the socialized project are those characterized by purposeful self activity combined with cooperative or mutual aid and criticism.

4. The most valuable aspects of individualization are preserved in an appreciation subject by this method. It is not a situation like mathematics, where each individual may forge ahead as fast as he wishes. Discussion, exchange of reactions, is also desirable and profitable. It is possible to combine them, retaining the best features of each.

5. The individual activities render possible a kind of physical participation which is within the powers of the pupils, intensifying interest and giving opportunity for creative expression.

6. The socialized project method is on the whole more satisfactory in the teaching of junior science than the conventional recitation-demonstration procedure.

WHAT EFFECT DO YOU HAVE ON YOUR PUPILS?*

By Ralph C. Benedict,
Brooklyn College, New York City.

There are three points of view from which the work of a teacher may be critically analyzed and evaluated: (1) the *attitude of the pupils* toward the teacher as an individual and toward the lesson and subject, together with any evidence of the acquisitions of distinctive habits of courtesy, neatness, learning, cooperation, thinking, and the like: (2) the *personality of the teacher as an individual,* and his attitude toward the children and toward the subject: (3) the *quality of the lesson as a piece of craftmanship.* In most rating blanks, emphasis is usually placed upon the last division, at least the blank commonly follows the arrangement of a formal lesson plan, with incidental opportunity for comments regarding the behavior of the children and the teacher's personality.

Is there any doubt that the most important of these three categories of measurement is the first? Is it not further certain that an experienced observer can arrive at a shrewd estimate of teaching ability merely by studying the effect of a teacher's personality and methods upon his pupils? Is it not also vitally important to keep in the foreground of attention, both for self-analysis, and in judging others, that the chief purpose of teaching is to influence children, to cause them to form new viewpoints, new attitudes, new habits? The teacher with the most efficiently organized lesson plan, the most logically organized presentation is not necessarily the most *influential* teacher; may often be quite the contrary.

For the reasons just indicated, there is presented below a rating form which is devoted entirely to the analysis of the reactions of pupils as a basis for judging the work of a teacher. It represents the first part of a longer form which covers all three of the rating bases mentioned in the first paragraph, all of which are necessary for a well-rounded judgment, especially after only a single recitation. Used over a period of several lessons, the pupil-attitudes criteria might furnish an entirely adequate evaluation of the work of a given teacher, but in a single lesson, there are entirely

*Prepared with special reference to science work, but general in application.

too many possibilities of factitious complications, beyond the influence of the particular teacher, to justify dependence upon this criterion alone.

In addition to outlining a classification of the types of pupil response, the blank suggests glossaries of possible characterizations by which the varieties and degrees of the responses may be denoted. It is believed that this series of adjectival specifications should be helpful, both to the individual teacher in self-analysis, and to the supervisor who may have to rate a series of teachers on a comparative basis. While in no sense proposed as a rigid or exclusive set of descriptive phrases, the words used do apply to a large number of the commonly experienced class situations. In most cases the terms are arranged in an ascending order of merit, but in others no set order is intended.

The blank applies particularly to recitations conducted by a teacher in his own class, and would be most appropriate several weeks after the start of a term. For rating a teacher conducting a recitation in a strange class or, at the beginning of the term, with a new class, it would be necessary to use also the parts of the rating blank relating to the personality of the teacher and his formal lesson technic.

A few years ago, Prof. Harry Overstreet wrote a stimulating book under the suggestive title, "Influencing Human Behavior." The words of the title present in epitome the teacher's problem but is easier to state a problem than to measure the degree of its attainment in actual practice. The first step in measurement of any complex process, such as teaching, is the careful analysis of the whole into its constituent elements, as is attempted in the blank below. However, it should not be expected that such an analysis, no matter how accurate and detailed, will be completely revelatory, any more than the chemical analysis of protoplasm into its constituent elements reveals the secret of living which the organized elements possess.

Fundamentally the problem of good teaching resolves itself into the question, "How much have you helped your pupils in the formation of better habits?"

SCORE SHEET

ANALYZING THE WORK OF THE TEACHER IN THE CLASSROOM

There are three main bases on which the work of a teacher may

be judged in the classroom; the attitude of the class to the teacher as an individual and to the lesson; the attitude of the teacher as an individual; and the lesson presentation and classroom technic as a piece of craftmanship. Each represents a different point of view. This sheet considers the work of the teacher as judged from the behavior, performance, and habits of his pupils.

I. Attitude of children toward teacher.
   (a) Entrance into the room; disrespectful; noisy; subdued; respectful; expectant and interested; friendly.
   (b) During starting routine: disorderly; noisy; other work; waiting quietly; preparing for class.
   (c) In absence of teacher: lid off; noisy; restrained talking; quiet; self direction.
   (d) Response to call to work: insubordinate; negative; slow; immediate. (Indicate few, half, or many.)
   (e) Personal attitude: dislike; disrespect; indifferent; respectful; cordial; friendly.
   (f) Attention: sullen; indifferent; quiet; cordial; enthusiastic.
   (g) Attention (amount): very little; half; general; complete.
   (h) Cooperation: little; half of class; general.
   (i) Responsibility: none noted; little; fifty per cent; general.
   (j) Desire to please: none noted; little; half; general.
   (k) Disrespect, if any: none noted; little; general; (or types) other lessons; whispering; dozing; day-dreaming; sotto voice comments; giggling; loud laughing; horse play; insubordination.

II. Attitude toward the lesson and subject.
   (a) Interest: none noted; little; fifty per cent; general.
   (b) Attention: (amount) very little; fifty per cent; general; complete.
   (c) Attention: (kinds) bored; languid; resigned; some interest; evident; eager.
   (d) Voluntary participation: none noted; same few repeatedly; half; many; practically all.
   (e) Interest in attainment: none noted; few; many; all.
   (f) Recognition of real problems: none noted; few; many; all.

III. Habits in work.
   (a) Self activity: none noted; few; fifty per cent; general.
   (b) Concentration: none noted; few; half; general.
   (c) Notebook work: none required; scanty; careless; satisfactory; painstaking; trivial matter; intelligent.
   (d) Persistence in thought: little or none; few; half; many.
   (e) Kind of thinking: scatter-brained; teacher-led; independent; cogent; clear; sequential; problem solving.
   (f) English: slovenly; poor pronunciation; ungrammatical; single words; disconnected statements; connected ideas and expressions.
   (g) Expression of thought: incoherent; irrelevant; muddled; fair; clear; sequential statements.
   (h) Posture: many careless; few careless; mostly good; too stiff.
   (i) Care of room: floor littered; marking on desks; feet on desk.
   (j) Self control: blurting out answers; hand waving; calling to attract attention; frequent; little; none.
   (k) Courtesy: to other pupils; volunteering before another finishes; waving hands; noisy; interrupting; few; little; none.
   (l) Honesty: prompting others; asking help; accepting help; sly reference to book or notes; insincere answers; none noted; few; half; many.

Using the Recitation Analysis Form as a Score Sheet

In preceding paragraphs emphasis has been placed on

the general importance of considering the reactions of pupils in forming a judgment of the work of a teacher in the classroom. The following section is devoted to an analysis of the blank as a score-sheet for the personal enlightenment of the teacher. The questions and discussion relate to its possible use in self-interpretation.

Are you teaching what your pupils want and need to learn, or are you presenting what you think they ought to learn; the things you are most interested in; the topics you studied in college science classes? Is their attention compelled or earned? Do most of them all the time and all of them some of the time cooperate in the lesson development or is the volunteer work done day after day by the same few? Do you sometimes make the lesson so interesting that the whole class is almost out of their seats in attention and interest, or do most of them merely sit quietly enough, but little intrigued by the day's work, or even engage in activities unrelated to the work of the period? Do they really find the work worth while? If so, how do they show it? How do you know whether they find it interesting?

These questions and many similar ones might be asked in making a study of the actual accomplishments of one's classroom work. The appropriate answers would depend upon a wide variety of factors; the teacher's personality, command of the subject, and methods of presentation constituting the controlling causes which make for success or failure. It happens frequently, however, that teachers of the finest personal qualities and preparation fail to realize the great contrast in viewpoint toward their science subjects which exists on the part of the children as compared with their own. For that reason, it is suggested that it may be specially helpful for teachers to use such a sheet to check their work, as a means of ascertaining whether they are teaching the subject or the pupils.

Assuming that such a study shows that the emphasis has been wrongly directed, how may one set about remedying the difficulty? In teaching, as in any other activity, habits lie at the bottom of performance. You cannot improve your pedagogical performance unless you are willing to analyze your methods and results, and can admit deficiencies. Besides self analysis, arrange to exchange visits with

other teachers for mutual criticism. Many faults may be so ingrained in habit, so much a matter of course to the individual, that it is impossible for him to recognize their existence unless pointed out by another. You cannot improve habits unless you realize the need for improvement.

Some teachers, like some ministers, tend to direct the major part of their attention toward one side of their audience. Some constantly repeat pupils' answers, parrot-like, and even try to defend the indefensible as an intentional effort for greater emphasis, "so that the whole class may hear," etc. The very answer convicts the teacher of having failed to stimulate the best activity on the part of the children. Furthermore, it is almost always true that the repetition of answers as a habit is associated with the general fault of teaching the subject, not the pupils. The teacher echoes the last answer as a half involuntary recognition that another item in his planned program for the period has been expressed, or "taught."

A study of the score sheet items will indicate that some are more important than others. Of the eleven items in group I, attitude toward the teachers as an individual, "cooperation" and "responsibility" on the part of the class mark the highest success a teacher may hope to attain. Ostensible respect, quiet, and immediate response to a call, may be compelled by forceful methods, but cooperation must be earned. Of course dignity and forcefulness are important but the teacher who relies on these mainly is achieving less than the greatest measure of success.

In the second series of items, the response to the lesson and subject, we find a reflection of the validity and success of the methods employed, as well as of the teacher's personality. The last two of these are most important. How can "recognition of real problems" be tested? How can it be developed? The same answer applies to both. Interest and its expression by wide spread voluntary questions and discussion are important criteria. Another lies in the reference of classroom activities to the home circle. Is there any better method of judging whether your pupils find their lessons worth while than by learning how often they take them home for further discussion?

SOME LESSONS ABOUT BEES.

By T. P. Webster, M. A.,

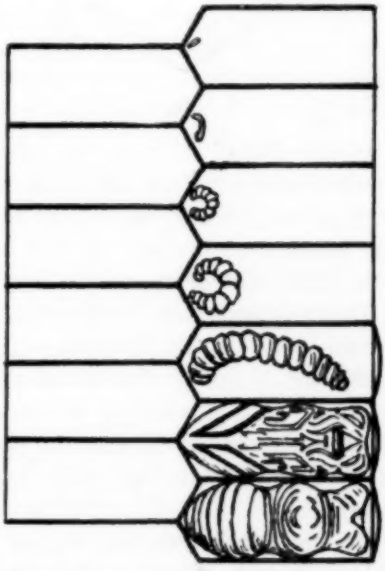
Allegheny Vocational School, N. S., Pittsburgh, Pa.

Lesson VI. The Bee as a Mathematician

In a glass case in the Congressional Library of Washington, D. C., is the geometry notebook which George Washington as a thirteen year old boy prepared for his teacher. It would be a very fine thing indeed if every boy in America might see that notebook. We are told that as a boy it was Washington's aim to do every task, however small, as perfectly as possible. The drawings in this notebook are just as exact as the drawings in your textbook.

In this lesson we hope to learn how very exact the honey bee is in the construction of the wax cells which are used as storage cells for honey and pollen and as cradles for the young bees.

The bee is extremely efficient and therefore very successful. Large apiaries of bees will average a surplus of more than one hundred pounds of honey per colony for the beekeeper. They need only fifty or sixty pounds for themselves over winter, so in a single honey gathering season of five or six months they accumulate three times the amount of their needs. This is like making in six months three times as much money as you need for a whole year's living expenses. Let us see whether the bee is an exact workman or not.



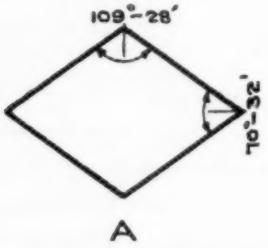
Eggs, Larvae and Pupae in Cells

Any one can see that the cells of the honey comb are six sided. If they were square it would take a much greater space to accommodate a given number of bees. This would be fatal to unhatched bees from a heating standpoint, and also to adult bees in winter.

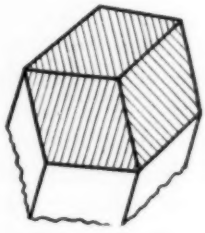
Any engineer will tell you that four sided cells would lack the strength of six sided ones. If the cells were round and they were grouped in the way the bee groups them, viz., one in the center and six all around it, equally distant from the central one and from each other, even then the circles would leave much waste room in the corners that the bees would have to fill with wax.

The queen will lay eggs only in cells that are near enough mathematical perfection to insure the comfort and well being of the young bees. Imperfect cells may be filled with either honey or pollen.

Wax is a very precious product, the bee using from seven to fifteen pounds of honey for each pound of wax. The bottom of the cell is not flat as this would not accommodate the round body of the bee and besides would leave useless corners just as if the cells had been made round or square. The bees have solved the problem.

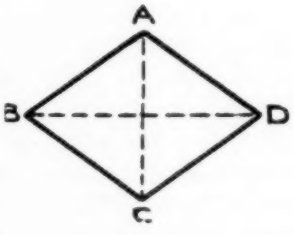


A



If the plate A were square the bottom would be too sharp-pointed to use the wax with the best economy or to best accommodate the infant bee. If the plate were longer the bottom of the cell would be too nearly flat to use the wax with best economy or for the comfort of the bee.

There is an exact proportion that the width of this plate should bear to the length. It is such that if the width of the plate is equal to the side of a square, the length should be exactly equal to the diagonal of this same square.



In the accompanying figure let A B C D represent the plate at the bottom of the cell and A C the width while B D is the length. It has been proven that

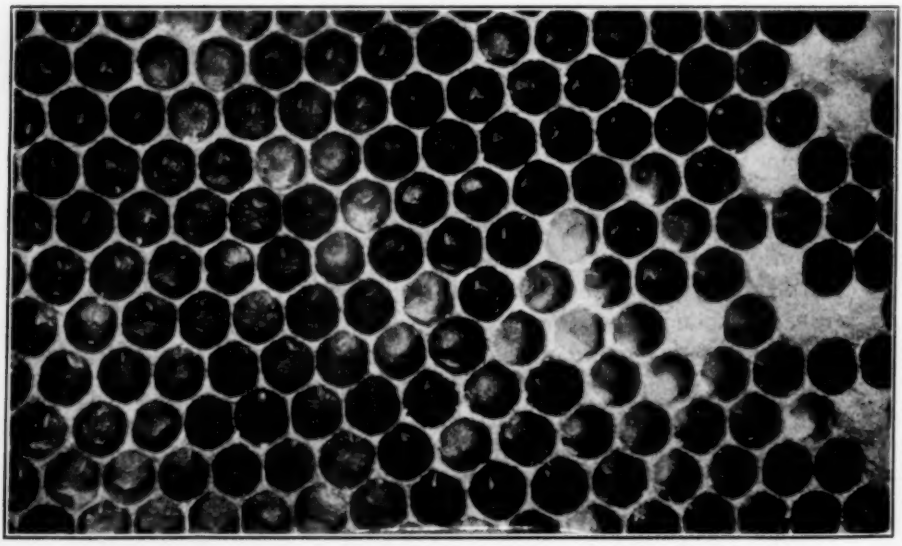
A C bears the same proportion to B D that the side of a square does to the diagonal of the same square. Geometrical accuracy in the shape of the cells can never be overdone and can be reached only by absolute perfection; and at this absolute perfection the bees have been constantly aiming through endless ages.

If a single cell be isolated it will be seen that the sides arise from the outer edges of the three plates described above so that there are of course six sides, the transverse section of which gives a perfect hexagon. Many years ago Maraldi, being struck with the fact that the plates always had the same angles, took the trouble to measure them, and found that in each plate the large angles measured 109° 28′ and the smaller 70° 32′, the two together making 180°, the equivalent of two right angles. He also noted the fact that the apex of the three-sided cup was formed by the union of three of the greater angles.

Some time afterward Reaumur, thinking that this remarkable uniformity of angle might have some connection with the wonderful economy of space which is observed in the bee comb, hit upon a very ingenious plan. Without mentioning his reasons for the question, he asked Koenig, the mathematician, to make the following calculation. Given a hexagonal vessel terminated by three diamond shaped plates, what are the angles which would give the greatest amount of space with the least amount of material?

Six-sided cells are a better proposition from an engineering standpoint. Lead pencils are six-sided for the same reason. Wood cuts up into six-sided pieces with no loss whatsoever. Take six six-sided lead pencils and fit them together so that they will merge into one larger piece with a hollow through it. A seventh six-sided pencil will just fit into that hollow. They would have been cut out of the larger piece with no loss of wood. There are no empty spaces between them. Koenig made his calculations and found that the angles were 109° 28′ and 70° 34′, almost precisely agreeing with the measurements of Maraldi. Reaumur, on receiving the answer, concluded that the bee had very nearly solved the difficult mathematical problem, the difference between the measurement and the calculation being so small as to be practically negative in the actual construction

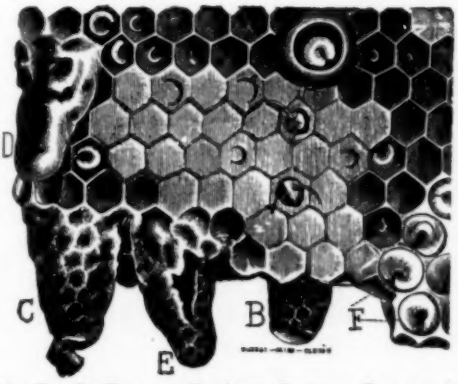
of so small an object as the bee cell. Mathematicians were naturally delighted with the result of the investigation, for it showed how beautifully practical science could be aided by theoretical knowledge; and the construction of the bee cell became a famous problem in the economy of nature. In comparison with the honey which the cell is intended to contain, the wax is a rare and costly product as before mentioned. It is, therefore, essential that the quantity of wax employed in making the comb should be as little, and that of the honey which could be stored in it as great as possible. For a long time these statements remained uncontroverted. Anyone with the proper instruments could measure the angles for himself and the calculations of the mathematician like Koenig would hardly be questioned. However, Maclaurin, the well-known Scotch mathematician, was not satisfied. The two results very nearly tallied with each other, but not quite, and he felt that in a mathematical question, precision was a necessity. So he tried the whole question himself and found Maraldi's measurement correct —namely, 109° 28′ and 70° 32′. He then set to work at the problem which was worked out by Koenig and found that the true theoretical angles were 109° 28′ and 70° 32′, precisely corresponding to the actual measurement of the bee



WORKER EGGS, SEALED AND UNSEALED WORKER LARVA IN CELLS.

cell. No engineer can design a plan for building wax cells that would be stronger or more economical of wax.

How did this discrepancy arise? On investigation it was found that no blame attached to Koenig, but that the error lay in the book of logarithms which he used. Thus a mistake in mathematical work was accidentally discovered by measuring the angles of a bee cell—a mistake sufficiently great to have caused the loss of a ship whose captain happened to use a copy of the same Logarithmic tables for calculating his longitudes.



A, B, C, D AND E ARE QUEEN CELLS, A AND B ARE BARELY STARTED. THE YOUNG QUEEN HAS HATCHED FROM C. SHE HAS KILLED HER ROYAL SISTER IN E. THE WORKERS HAVE PREVENTED HER FROM KILLING THE YOUNG QUEEN IN D. F SHOWS BABY DRONES IN THEIR CELLS. NOTE ALSO THE CRESCENT SHAPED WORKER LARVA IN OTHER CELLS.

An important thing to remember at this point is that some cells in the honey comb sometimes are imperfect because summer heat causes the wax walls to sag. These cells are used for storage of honey and pollen. The queen who is the mother of all the bees inspects each and every cell very carefully and lays an egg only in cells whose angles are geometrically perfect. We do not give the bees credit for reason or thinking ability because they are to a certain extent incapable of making mistakes in cell building. What you must remember is that the insects who are so successful are also painstakingly exact in their work. Precision and exactness are always the marks of expert workmanship.

No workman of any kind ever achieved excellence without great attention to minor details. "There is no excellence without great labor." "Labor conquers everything." "Genius is eternal patience."

"In the elder days of art
Builders wrought with greatest care
Each minute and unseen part,
For the gods see everywhere."

CHECKING AND GRADING LABORATORY DRAWINGS.

By Horace Gunthorp,
Head of the Department of Biology, University of Arizona, Tucson, Ariz.

Two of the bugbears of teaching are the grading of examination papers, and the correcting and grading of laboratory drawings. The "Yes or No" and completion forms of examination question have the undoubted merit of saving the teacher much drudgery regardless of any bad pedagogical points they may have, but no such short cut to labor saving has as yet been devised to help the biology teacher in connection with the many and various drawings with which he has to cope, especially in elementary courses. The following method can not pretend to be a cure-all by any means, but it has proven somewhat of a help, and at least saves the teacher's home time even if it does make the class hour a bit more strenuous, especially when the classes are large.

The usual method of handling laboratory drawings is to gather them up at the end of the hour, carry them home, and at one's leisure correct and grade them. The corrections are usually made directly on the drawings in a blue or red pencil, and a grade is given either for the day's or the week's work, as the teacher sees fit. There appears to me to be no less than four bad points to this method. First, if the same result can be obtained during the laboratory hour, all time spent on the drawings at home is wasted, and can be used much more profitably in any of a dozen other ways. Second, marking up a student's drawings makes the work look bad, and the stressing of neatness and order in the classroom largely loses its point. Third, the grade given represents what

the teacher thinks of the drawing as such, and all conception of the student's attitude toward his laboratory problems, and his ability to dissect are lost sight of; in short, the emphasis is placed on the mere recording of observations, and the more vital scientific points are not considered. As a result, the pupil's final grade will place emphasis on examinations and ability to draw—the latter a matter of little biological value. A fourth objection is the fact that it is practically impossible to judge what a student amounts to in the laboratory part of the work by placing grades on isolated drawings and recorded observations. It is necessary to have a larger body of his work before one at a given time, and also to have his general attitude and dissecting ability in mind. All of these four points are taken care of by following the method as outlined below.

In the first place, examine the drawings in laboratory right in front of the student, and call his attention to any mistakes that may occur. This enables the student to use his specimen to help him make the necessary corrections. It is obvious that the more prompt the teacher is in making this first check, the less time will be wasted by the student and the more likely the specimen is to be in the exact condition it was when the drawing was first made.

If you wish to make a note on the drawing itself, put it along the left hand margin in pencil where it will be either bound out of sight if the book is eventually tied with string, or if in a loose leaf holder, it will at least be inconspicuous. This jotting of the mistakes down along the margin serves the double purpose of providing the student with a check of his own mistakes, and of reminding the teacher of former corrections. Also if the corrections are made along the margin and not directly on the drawing, the student has to not only interpret these written instructions, but to actually work them out and make them a part of his drawing himself. A drawing may be examined more than once before it is approved, of course. As soon as it is correct and properly labeled, place an O. K. consisting of the initial of your first name in the extreme lower left hand corner of the page. Make no attempt to grade the work at this time,

but let this matter wait until a more general survey or summary can be made, say three or four times during the semester only.

Once a week or so, a second O. K. consisting of the initial of your last name, can be placed directly following the first initial on each drawing that has a first O. K. already on it. This can also be done right in the laboratory during the regular work session, and really takes very little time. As each drawing is given its second O. K., a record is made in a class book set aside for this purpose. All this book will have in it will be the names of the students, followed by enough columns to cover the total number of drawings and experiments that will be in the course. Each drawing is given a consecutive number, and a vacant space following a name indicates back work not finished in a satisfactory manner. In order to more quickly check on a student while instructing him, I enter these check marks for the drawings in pencil, and then run a zigzag line with pen across these checks from left to right, stopping the line at the point where I find the first vacant space. A judicious showing of the record has a good effect in bringing up the backward ones.

Of course if a check system like the above is used, it is essential that the instructions be both clear and exact. There are several satisfactory laboratory manuals on the market that will cover this, or mimeographed instructions can be given, or even oral ones. However, the latter method is usually practical only with an experienced teacher. Personally, I use a laboratory manual in which all labels are in italics, and then I supplement this with some general remarks regarding each problem and dissection. Even then, the matter does not always permeate.

The above method of double checking all laboratory work during the class period not only saves the time of the instructor, but also gives him a chance to postpone the giving of grades until enough work has accumulated so that a more accurate judgment can be passed on it. Also, it in all probability more often guarantees that the pupil does the work himself without too much help from the teacher, which is in line with the true spirit of science teaching.

SCIENCE INSTRUCTORS TAKE ACCOUNT OF STOCK.

By A. C. MONAHAN,
Formerly U. S. Bureau of Education.

What does the science instructor need for effective science teaching in addition to his general qualifications as a teacher and his special training in the sciences, and his determination to make his courses the outstanding courses given in the school? His subjects are laboratory subjects, outlined largely for individual pupil laboratory exercises. He must therefore have a satisfactory laboratory, with plenty of room for his pupils to work, with well designed and built laboratory furniture, and with satisfactory apparatus, tools and supplies. The best qualified instructor can not do good work otherwise.

In visiting schools throughout the country one finds very few home economics instructors trying to teach their subjects without satisfactory equipment, or teachers of the industrial arts, drawing, drafting, typing, bookkeeping or music, without adequate facilities. But one *does* find very many science teachers trying to carry out their work in laboratories entirely inadequate in space, furniture, apparatus and supplies. Also one finds many such laboratories, and even some in which good furniture and apparatus had been installed, in a condition of disorder that creates a wonder why any pupils at all elect the courses offered. As a matter of fact few girls do where not required by outside influences. They prefer the art and home economics rooms which as a rule are found in a neat and orderly condition. The remedy is of course apparent.

For the science teacher to get adequate space for his work, good furniture, and satisfactory apparatus, the problem is more difficult. He has to go to his principal and superintendent and show them the needs. As a rule they are not scientists and are without sufficient information to know what is required. The science instructor has, therefore, to educate them relative to the needs of a science laboratory. First he should be sure that he knows himself the requirements. One might assume that he does know, but this is not always the case. The writer was told by the chairman of the science section of a State Teachers Association within the year, that when she needed a new

chemistry table she got a "local carpenter to come into the laboratory and build it." What would one think of a home economics instructor who got a local carpenter to build her cooking and sewing tables in her laboratory, or an arts teacher who had her drawing tables built the same way, or a teacher of Latin who had seats and desks in her recitation room built by a carpenter in the room. It used to be the custom to have furniture needs taken care of that way, but it is not now—except in the case of certain science teachers who have never used well designed and built furniture in their laboratories and fail to understand the extent of the influence good or bad furniture has on the accuracy, exactness and neatness of the pupils' work. Science is an exact subject. One can not expect careful exact work on the part of pupils in an unsightly laboratory and with poorly cared for instruments.

With school officials the situation is different. Few of them have any reason to know what a satisfactorily equipped laboratory looks like. Even some good authorities on school buildings have peculiar ideas on this subject. The late F. B. Dresslar, regarded as a leading consultant on school buildings, in a bulletin published in 1924 by the U. S. Bureau of Education,[1] said:

"But, as all who have worked in a chemical laboratory know, it is only a matter of weeks until such tables are blistered, stained or discolored until they are unsightly, and it seems unnecessary to use expensive lumber and go to the trouble of polishing or varnishing it, as is done with furniture in general."

Contrast that statement with the following made by Dr. John N. Swan, one of the leading chemists in the country, Professor of Chemistry for many years at the University of Mississippi, and Chairman of the Chemical Education section of the American Chemical Society. In a report to the *National Research Council* of Washington, D. C., published by *Chemical Foundation* of New York, he says:

"The tables (student chemistry tables) should have incorporated in them whatever has been found excellent in service. Utility is the main consideration, and this should be coupled with permanence under the severe test of con-

[1] *American School Houses*, Bulletin 1924, No. 17.

tinued use. Then, too, the tables should have a neat and staple appearance, for they should give the student ideas of neatness and solidity. * * * The best makers of laboratory tables use oak wood in their construction, and nothing has been found which will give better or longer service. It is not necessary that this be given a piano finish, and yet it is quite essential that the table have a neat appearance as well as a long and useful life. The cabinet parts of tables should be finished with a coat of filler and three coats of cabinet rubbed varnish, sanded between coats. The wood should be stained to harmonize with the finish of the room."

The instructor in science, before he can educate his officials in what constitutes a real laboratory for a high school, must acquaint himself with some good school laboratories. He will not have far to go to find such, as many are to be found in all parts of the country. Also he can consult such authoritative reports as the one from which the quotation from Dr. Swan was taken. This was prepared by a committee of six leading college and high school instructors in the United States, selected from various sections so that the committee would be representative. Its title is *Laboratory Construction and Equipment.* He can obtain from the United States Government Printing Office a copy of a Bureau of Education Bulletin entitled *Laboratory Layouts for the High School Sciences.* This deals primarily with the requirements for the smaller school. Another publication of much value is a report just off the press issued by the Massachusetts State Department of Education entitled *Report on Equipment, Apparatus and Materials for Teaching Science in Secondary Schools.* It was prepared by a committee of five science instructors, four of whom are leading high school men of the State, the fifth and chairman being Dr. N. Henry Black of Harvard, the author of several well known high school science text books. Teachers College, Columbia University, has several publications of assistance on this subject. Included among them is the high school score card prepared by Drs. Stayer and Engelhart, and a bulletin entitled *A Description of the Science Laboratories of the Lincoln School.* All of these publications have illustrations of representative laboratories in

various States and give descriptive matter relative to layouts and furniture.

Relative to apparatus and supplies, the science teacher has many good lists available against which he can check the items of equipment in his own laboratories. The government bulletin mentioned above has a modest list prepared by six high school science instructors, and includes sufficient to cover the requirements of the various state departments of education for accrediting. The Massachusetts bulletin mentioned has more complete lists. They include what the well equipped high school ought to have for modern science courses. Large city high schools with heavy enrollment in the science courses are warranted in supplying their departments with considerable more than is given in these Massachusetts lists.

Approximately 30 State departments of education have prepared lists of apparatus[2] which they use in accrediting high school science courses. Copies of these may be obtained from the departments. It must be remembered that they are practically all *minimum* lists, being the essential items of equipment for State approval. They correspond closely to the lists in the government bulletin mentioned above.

It would be well for every science instructor to obtain one of these standard lists, and on it enter against each item the articles in his own supply, together with the condition of his articles. He will then have something tangible to use with his principal or superintendent, and which they can use with their school boards when requesting money for the needed items. Without such proof of his needs it is difficult to see how he can expect much of an allowance from his superiors.

[2]SCHOOL SCIENCE AND MATHEMATICS has a limited number of these State lists from the various States and will be glad to send them free to readers of the Journal.—Editor.

It is now possible to measure pressures as high as 600 atmospheres, or 9000 pounds per square inch, with an error of only one part in ten thousand, said Dr. F. G. Keyes of the Massachusetts Institute of Technology at the meeting of the American Chemical Society. The device used is a "dead weight gauge" or piston.

COMPARING THE EFFECT OF ARITHMETIC AND GENERAL MATHEMATICS TRAINING IN THE SEVENTH AND EIGHTH GRADES UPON ACHIEVEMENT IN NINTH-GRADE GENERAL MATHEMATICS.

BY C. N. STOKES,

University of Minnesota.

In accordance with the accepted principles which imply our modern philosophy of secondary education and specify the functions peculiar to our junior high school, the primary purpose of the teaching of mathematics is (1) the development of the powers of understanding and analyzing quantitative relationships that are essential in the appreciation of the development of civilization and in the understanding of the qualitative and quantitative values of the every-day activities of life, and (2) the development of habits of thinking that will cause these powers to be effective in the work of the individual as he engages in the normal duties of life. In other words, the individual's training in mathematics should contribute toward the rounding-out of a well ordered life. The materials of instruction in any course in any year of this training should be of such a nature that the individual receives the most valuable experiences, mathematical information, and methods in accurate thinking for which he is likely to have need in adult life should his education terminate at the end of that year. Hence, each year's work is an entity within itself, and, in the planning, little regard should be paid to that which follows.

In attempting to attain these standards (qualitative), it has been proposed that the only logical materials for instructional purposes which will fit into the scheme are those of the generalized type. The arguments made by the proponents of this proposal are scattered profusely throughout the literature; they do not need to be re-presented here. We find however that many school officials do not hold this point of view for they are still offering the more or less traditional type of arithmetic in the seventh and eighth grades and a generalized course in the ninth. In situations of this type the faith is, perhaps, that the desirable outcomes are achieved. The question here is whether this type of training in the seventh and eighth grades is a better (or poorer) preparation for a generalized program in the ninth

grade than that where the materials of instruction are in accord with the proposal stated above.

METHOD

The method of attack used in obtaining pertinent data dealing with the point under discussion was to submit pupils who had had the respective types of previous training to a general course in the ninth grade and in so far as was possible determine their achievement with a view toward interpreting these data as the probable effect of that previous training.

The data for the discussion were obtained from pupils in the ninth grade of the University High School, University of Minnesota, during the three academic years 1927-29 inclusive. These pupils had had their previous two years of training either in the public and private schools of St. Paul and Minneapolis or the University High School. In this situation it was found that we had sufficient data on 66 pupils who had studied arithmetic and 128 who had studied general mathematics to include them in the study.

The instrument used to determine the status of their mathematical attainments in the ninth grade was the Reeve General Mathematics Composite Scale (See monograph—W. D. Reeve, A Diagnostic Study of the Teaching Problems in High School Mathematics. Boston: Ginn and Company, 1926). One form of the scale (indicated below as the inventory scale) was administered the first week of school in September and another at the end of school in June. The difference in the scores made on these two forms of the scale represented the pupil's achievement.

The procedure took into account also the initial arithmetical knowledge of the pupils as measured by the Buckingham Problem Scale and the Woody Fundamentals Test (Van Wagenen revisions) and the median I. Q. resulting from the administration of five well known intelligence tests —Terman Group, Form A; Miller Mental Ability, Form A; Army Alpha, Form 8; Haggerty, Delta 2; and Pressy Senior Classification, Form A.

THE DATA AND THEIR INTERPRETATION

The group that studied arithmetic in the previous grades is Group I in the table below and the group that studied general mathematics is Group II.

TESTS	GROUP I (66 Pupils)		GROUP II (128 Pupils)	
Fundamentals	Mean, 88.3	Sigma, 7.2	Mean, 74.2	Sigma, 12.4
Problem Solving	Mean, 73.5	Sigma, 6.3	Mean, 89.8	Sigma, 7.6
Inventory Scale (Sept.).....	Mean, 52.1	Sigma, 7.2	Mean, 53.2	Sigma, 7.4
Achievement	Mean, 25.7	Sigma, 4.8	Mean, 32.4	Sigma, 6.2
Intelligence (I. Q.).....	Mean, 118.6	Sigma, 10.7	Mean, 119.5	Sigma, 11.2

It is observed from these data that the previous knowledge of arithmetic varies somewhat when the different types of work in the seventh and eighth grades are considered. The group pursuing the arithmetic courses surpass those in the general mathematics group in fundamentals, while the situation is reversed in problem solving. Not having the necessary data from which a safe conclusion may be made, it seems a matter of speculation that the type of training in these grades may have had something to do with the results. On the other hand, when these two indices are averaged* it is noted that the two groups are approximately equal. The records of performance on the inventory scale indicate a slight advantage in favor of the general mathematics group (Group II). However, the difference is not significant as determined by the critical ratio $\frac{D}{\sigma diff}$. Its value in this case is .99.

Now, with an average I. Q. of 118.6, an arithmetical ability represented by 80.9 (average of the two measures in arithmetic), and a previous knowledge of the subject represented by a score of 52.1 on the Reeve scale for the arithmetic group, and an average I. Q. of 119.5, an arithmetical ability of 82, and a previous knowledge score of 53.2 for the general mathematics group, it is evident that, as far as some of the important factors in learning ninth-grade mathematics are concerned, both groups are comparable. However, the data on final achievement do not indicate that they learned equally well. With a difference of 6.7 points in the mean scores and a certainty of occurrence of 1000 chances in 1000 ($\frac{D}{\sigma diff} = 8.29$) that the difference is a true one, we may safely conclude that the achievement of the group that studied general mathematics was the greater.

Using Pearson's chi-square test to verify the significance of this difference, we find that the chances are 852 in 1000 that a difference as large as this arise from different populations, or that there are only 148 chances in 1000 that a dif-

*Averaging these arithmetic scores introduces no appreciable error. See Van Wagenen, M. J. A Teachers Manual in the Use of Accomplishment Educational Scales. Bloomington, Illinois. Public School Publishing Company, 1925, 187 pp.

ference of this magnitude would arise from random sampling of the same population.

Another check on the probability of association between the types of previous training and achievement in ninth grade may be expressed by the bi-serial r. In a dichotomic distribution where we have only categorical information, as in this situation, it expresses the relation between receiving previous training in arithmetic (rather than in general mathematics) and achieving better (or poorer) in ninth-grade general mathematics, as measured by the Reeve scale, than at least two-thirds of the total group. Its value here is —.23 ± .04 which is comparatively low yet significant. This is further evidence that there is a probability that differences in previous training really account for significant differences in achievement in ninth-grade general mathematics.

Further relationships between previous knowledge of mathematics and final achievement in ninth grade, as measured by the instruments used here, are seen in the coefficients of correlation of the zero order. For these we have

	Arith. Group	*Gen. Math. Group.*
Problem solving—Achievement	23.7 ± .08	54.7 ± .05
Fundamentals—Achievement	14.4 ± .06	12.3 ± .08
Inventory—Achievement	23.5 ± .09	43.6 ± .04

These findings seem to indicate that whatever it is that aids the pupil in problem solving and in the test which is purported to measure previous knowledge of the subject of ninth-grade general mathematics is also a factor in final achievement.

A point which comes to our attention here and which would be worthy of consideration is just how much of these prerequisite courses is needed for successful pursuit of the subsequent course. The differences in amount of the two types of arithmetical knowledge in possession at the end of the eighth grade and the relatively low correlations between these and achievement in the ninth grade seem to justify the need for determining just what elements of the former are of functional value in the latter. This would call for extended analyses and experimentation which are beyond the scope of this discussion.

In summarizing, it may be said that the data indicate that we have differentiated samples, or, other things being equal,

that the types of previous mathematical training are differential in their effects as far as achievement in ninth-grade general mathematics by the samples dealt with are concerned. The group that studied general mathematics in the seventh and eighth grades seems to be superior to the group that studied arithmetic in achieving general mathematics in the ninth grade. Then, if the aims and purposes of training in secondary school mathematics are achieved in part in ninth grade general mathematics, it seems safe to say that it would be better to have pupils study general mathematics rather than arithmetic in the prerequisite courses in the junior high school.

A PROJECT FOR THE PHOTOGRAPHERS.

By KARL F. OERLEIN, *Senior High School, Upper Darby, Pa.*

The latest activity of the photographic section of our Science Club is the work done for the supervisor of the elementary schools of the district. It is the plan of the supervisor to compile a book on grade school projects. Throughout the eight elementary schools of the district many excellent projects have been made. In order to have a permanent record of these as well as to illustrate the contemplated book the supervisor asked the club to photograph the projects. Each project is photographed twice; once, closeup for details, and, second, with the children who made it included. It is the wish of the supervisor to make the book a project from beginning to end. Not only have the projects been made by the elementary school children but the photographs and illustrations of them are being made by the club members.

Another activity engaged in this fall for the first time and, therefore, still under experimentation is the troupe project. At the present time two troupes have been organized for this work but this number will be increased if the plan works out well. The plan is to have several members (about three or four) constitute a troupe. Each troupe is planning a scientific show of experiments suitable for elementary school pupils. No duplication is permitted between the troupes and the programs are being made flexible so that the running time may be varied to suit the occasion. After the performances have been thoroughly practiced the troupes will go out to the elementary schools on a regular circuit giving performances in the assembly periods.

The chief difficulty with the projects just mentioned is the time required of the members from their regular classes. This has been taken care of in the same way as pupils excused for athletic purposes. Members of the club are excused by the teachers much less reluctantly than athletes because the members being selected on ability are, on the whole, better scholastically than the athletes.

EASTERN ASSOCIATION OF PHYSICS TEACHERS.

One Hundred Eighteenth Meeting

PHILLIPS ACADEMY

Andover, Mass.

SATURDAY, MAY 23, 1931

Room 26, Samuel F. B. Morse Hall

PROGRAM

9:30 Meeting of the Executive Committee.
10:00 Business Meeting.
10:15 Reports of Committees.
10:30 Address: "New Principles in Oil Burners." Mr. Percy S. Brayton. (Mr. Brayton is a former member of this Association.)
11:00 Demonstration of Motion Picture Films for Classroom Use. Mr. George A. Gould of Eastman Teaching Films, Inc.
11:45 Address: "Some Developments in Communication." Mr. Joseph W. Cassidy of the New England Telephone and Telegraph Co.
1:00 Luncheon. Price, seventy-five cents.
1:45 Address: "The New Physics and the Secondary School." Prof. Edwin C. Kemble, Harvard University.
2:15 Address by Dr. Alfred V. Kidder, Chairman of the Division of Historical Research, Carnegie Institution of Washington, D. C.
3:15 to 5:00 The new Addison Gallery of American Art will be open to the members of the Association.

OFFICERS FOR 1931-1932.

President, Frederick M. Boyce, Phillips Academy, Andover, Mass.

Vice-President, Lawrence A. Howard, High School, East Boston, Mass.

Secretary, William W. Obear, High School, Somerville, Mass.

Treasurer, William F. Rice, Jamaica Plain High School, Boston, Mass.

Committees.

Executive—Arthur V. Donellan, Jamaica Plain High School, Boston, Mass.; Ralph B. Delano, Memorial High School, Grove Hall, Mass.; Robert W. Perry, High School, Malden, Mass.

New Apparatus—John C. Packard, High School, Brookline, Mass.; Hollis D. Hatch, English High School, Boston, Mass.; John T. Gibbons, High School, Brighton, Mass.

Magazine Literature and New Books—William E. Smith, English High School, Boston, Mass.; Francis J. O'Brien, High School, Lawrence, Mass.; Laurence D. Somers, Tabor Academy, Marion, Mass.

Current Events—Clarence M. Hall, Central High School, Springfield, Mass.; Daniel J. Shea, High School of Commerce, Boston, Mass.

College Entrance Requirements—Frederick E. Sears, St. Paul's School, Concord, N. H.; Francis E. Mason, High School of Commerce, Boston, Mass.; Burton L. Cushing, Mechanic Arts High School, Boston, Mass.

Membership—Fred R. Miller, English High School, Boston, Mass.; Homer W. LeSourd, Milton Academy, Milton, Mass.; Roy R. Hatch, Mt. Hermon School, Mt. Hermon, Mass.

BUSINESS MEETING.

The following were elected to membership:

Active—Alfred G. Baldwin, Phillips Academy, Andover, Mass.

Associate—William M. Edmonstone, Roxbury Memorial High School for Boys, Boston, Mass., 14 New Bedford St., Hyde Park, Mass.; Charles W. Skinner, High School, Arlington, Mass., 21 Pine St., Arlington, Mass.

It was voted that the thanks of the Association be extended to Phillips Academy for its hospitality and to the speakers and others who helped in arranging this meeting.

REPORT OF COMMITTEE ON CURRENT EVENTS IN PHYSICS.

By Clarence M. Hall, *Chairman, Central High School, Springfield, Mass.*

From The Scientific American:

The quantum is discussed by Paul R. Heyl and the statement made that interference can only take place between parts of the same quantum, from which he arrives at the idea that a quantum may be several feet in diameter and nearly two feet long, for a large lens. The quantum may be as large as 18 ft. diameter, as Michelson's star work was done on light rays 18 ft. apart in the interferometer.

Lightning produces yearly, free of charge, about 100,000,000 tons of fixed nitrogen.

By use of a sheet of material containing radium, it is now possible to get x-ray pictures of castings, to determine flaws, better than by the x-ray tube itself and at less expense.

In making concrete hollow piles, the concrete is spun at 400 revolutions per minute for 10 minutes. This centrifugal force moulds the concrete against the mould, making a very dense mass with a minimum of water.

A new stroboscope has an electric circuit which causes a condenser to discharge periodically through a thyratron mercury-arc tube. An intense blue actinic light of extremely short duration, precisely timed to correspond with the speed of the machine under observation, makes it possible to take photographs of moving objects in a hundred thousandth part of a second.

Thirty million volts pressure is now possible by a modification of the Faraday cage effect. By using such voltages on a gigantic x-ray tube to accelerate the positively charged cores of hydrogen atoms, man will have the most powerful projectile ever available, resembling alpha rays from radium.

From The Springfield Union:

An autogyro record of 18,500 feet altitude has been made by Amelia Earhart. The motor was 300 horsepower.

The new navy submarine, Nautilus, has succeeded in diving to 336 feet.

Two feet square television pictures for the home are now possible. The Western Television Company uses a scanning disc containing lenses instead of holes, and a more powerful glow lamp. At a theater, a ten foot screen can be filled.

The Bureau of Standards has liquefied helium at three degrees Fahrenheit above absolute zero and finds that at this temperature tin becomes 100,000 times better conductor than at ordinary temperatures.

To clarify sound it is now sent through water by many resonating tubes and the water surface finally emits the purified sound to the audience.

By photographing the light of atoms, making use of the Raman effect and reducing the light frequencies to audible ones, it is possible to listen to chords of music as produced by such atoms as benzene, water, alcohol.

At California Technology, a new wind tunnel gives air velocities of 240 miles per hour, using a 500 horsepower engine to drive the propeller.

A discovery that the eye sees five colors is claimed by Prof. Rinde of California. These five primary sensations produce all the colors we see. He lists them as red, yellow, green, blue, violet. The area of the retina for yellow is largest.

The mile long vacuum pipe line experiment on the velocity of light is completed, but the calculations are yet to be made. The recent death of its originator, Dr. Michelson, is a real blow to Physics but he has left a splendid monument in his incomparably accurate work.

On the very field where, thirty years ago, Orville Wright first flew, he saw, May 17, a fleet of 500 planes pass over the scene.

Dr. Stetson of Perkins Observatory says that an apparent depression occurs in the Heaviside layer of electrons, when the moon is overhead, suggesting that the moon is an electrostatically charged body and affects radio reception.

A daring idea that creation began in one single vast atom is advanced by Le Maitre of Belgium. He bases it on the quantum theory, stating that there were fewer quanta formerly, and that a long time ago there may have been only one. The atomic weight of the original atom would be the total mass of the universe.

Moreno, a Mexican optical engineer, has invented a motion picture camera with continuous movement of film. It has no shutter and is silent. The exposure time on the film is twice as long as usual, allowing 50 per cent less illumination. Color can be reproduced accurately. In his projection machine, the flicker is eliminated and the fire danger cut, since the amount of light is cut in half.

REPORT OF THE APPARATUS COMMITTEE.

By John C. Packard, *Chairman, High School, Brookline, Mass.*

The following pieces of apparatus were exhibited:

1. A tiny synchronous motor, of wide open construction, easily dissectible, and adapted to run on a 110-volt A. C. electric circuit while held in the palm of one's hand. An excellent device to illustrate the principle of an induction motor and its application to various time-keeping devices. Made by the Eastern Science Sales Co., of Brookline, Mass., as a model for the driving mechanism of an astronomical telescope, to be used in place of the usual design run by a weight and regulated by a centrifugal governor or by an escapement.

2. A 4 x 5 camera consisting of but little more than a lens, a bellows and a ground glass, mounted upon an adjustable stand, to be used as a basis for the work upon optical instruments in the course on light. When mounted against a hole in the shutter of the dark-

ened lecture room, with the lens outermost, a brilliant picture of all outdoors, depicted upon the ground glass, can be seen clearly by all the pupils in the room. A reading glass placed a few inches from the ground glass takes the place of an eye-piece and, with the picture in focus, shows clearly the principle of the compound microscope and the celestial telescope, while if the distant scene is viewed through a small hole made in the ground glass (or a waxed paper substitute) the real image is shown, actually, to be formed in the air and to be quite independent of the screen. Returned to the lecture table, a lantern slide is substituted for the ground glass, the reading glass is used as a condenser, a bright light is thrown through the slide, the picture is projected upon a screen and the principle of the stereopticon is illustrated. Highly effective if the picture is a copy of the scene depicted by the camera in the first place.

3. A series of home-made revolving lantern slides showing the action of the armature in an A. C. generator and a D. C. dynamo.

4. A working model of a Morse sounder and a relay, the brass parts made of wood and the whole mounted between a pair of glass plates to be projected upon the screen, after the manner of a lantern slide and operated by a dry cell. Most interesting if connected in series with a commercial sounder so that the clicks can be heard at the same time that the armature is seen to move.

5. A working model of an electric motor made by one of the boys in the laboratory from the parts of an old bell. Ingenious!

NEW PRINCIPLES IN DOMESTIC OIL BURNERS.

BY PERCY S. BRAYTON.

In view of the fact that the State Fire Marshal of Massachusetts has approved more than 250 oil burners, some one is going to ask me, "Why another Oil Burner?" I imagine that the following are some of the considerations which led the Walworth Company of Boston to design and market another: (1) the elimination of all electricity and gas; and (2) a reduction in the retail price.

It is desirable to eliminate both gas and electricity not only because of the initial and maintenance costs of thermostat, motor, fan, electric ignition or gas pilot, etc., but also because of the possibility of failure of either gas or electricity because of decreased pressure or broken wires. It is only a few years ago that an ice storm in Boston and vicinity broke down wires and left many houses without electricity for as long as ten days.

In the second place, the elimination of expensive electrical equipment has made it possible to furnish an Oil Burner with thermostat and 275 gallon oil tank installed ready to light for $280, a price much below any

other oil burner with forced draft and thermostat control so far as I have been able to determine.

The general principles involved in this type of Oil Burner are (1) the use of a steam jet at a constant pressure of about two and one half pound to atomize the oil and produce the forced draft necessary for complete combustion; (2) continuous oil burning, that is, the use of an oil pilot in place of a gas pilot or electric ignition; and (3) a control of the heat depending wholly on the amount of oil burned, the supply of oil being increased or decreased automatically.

The use of a steam jet involved an entirely new design. The Burner sets on the cellar floor with the combustion chamber sealed into the ash pit of the heater. Outside is a small water tank connected with the city water supply by means of a float cock. From the bottom of this tank a pipe leads to the steam generator which surrounds the combustion chamber. The steam generated is piped to the oil burner and the oil is dropped directly into the steam jet, atomizing the oil. The steam jet also draws air through into the combustion chamber producing complete combustion of the oil. This avoids all smoke and soot. A steam gauge and a relief valve for maintaining the constant pressure at two and a half pounds are mounted in plain sight. The air supply is fed through a felt lined muffler which minimizes the noise.

In starting this burner, fuel oil or kerosene is poured on an asbestos pad underneath the oil burner. This oil is then lighted with a match. After a couple of minutes the oil supply is turned on. The natural draft carries the flame into the combustion chamber where within a few minutes the steam is generated increasing the draft. This burner can be lighted in the fall and allowed to burn continuously until it is shut off in the late spring. In the fall and spring, it can be readily put out and relighted at any time if desired instead of burning continuously. It takes only a few minutes to light it.

The thermostat used is mechanical rather than electrical as in other burners. Attached to the wall in one of the living rooms is a copper diaphragm or bulb four and

one half inches in diameter partially filled with a very volatile liquid. A small bore copper pipe filled with sodium sulphate solution and concealed in the wall connects this diaphragm with a cylinder in the cellar above the heater. An increase in temperature in the living room will cause more of the volatile liquid in the diaphragm to vaporize increasing the pressure above the liquid. A decrease in temperature will condense part of the vapor in the top of the diaphragm decreasing the pressure of the vapor. This change in pressure is transmitted through the brine solution (sodium sulphate) in the copper pipe to the cylinder in the cellar. The motion of a piston in this cylinder, magnified by a lever system, is transmitted by a chain to the needle valve controlling the oil flow. When the temperature in the living room is raised, the needle valve is partially closed and the amount of heat delivered to the heater is decreased while a decrease in temperature in the living room increases the oil supply. The slightest change in temperature affects the oil supply to the burner. There is no waiting for a change of a degree or more before the thermostat can affect the burner.

There remains for consideration only the cost of heating a house with such a Burner. In the first place there are no bills for gas and electricity and the water used will cost less than a dollar a year for a large house. There are no moving parts to wear or need frequent lubrication. The fuel used is 28° to 32° fuel oil which at the present time costs six and one half cents per gallon in Boston and vicinity. This oil is not only cheaper than the lighter oils but contains more heat units.

Actual house use has shown that in almost every case the cost of oil for such a Burner has been less than the cost of coal used in the same heater, and moreover the houses have been kept at a temperature of 70° F. or whatever temperature is desired, both night and day. The saving in some cases has been more than 30% of the coal bill of the previous year.

DOMESTIC HUMIDIFICATION.

Is your house drier in winter than Death Valley? An

official Bulletin published by the Canadian Government states that the average humidity in houses in Ottawa in the winter is from ten to fifteen per cent. Death Valley averages twenty-three per cent.

Since primitive times we have made great improvements in our methods of heating our houses but we have made very little advance in overcoming the resulting dryness. When we ventilate our houses in winter we bring in outdoor air at a comparatively low temperature. As we heat this air to normal house temperature, the relative humidity falls rapidly. Air which is saturated at 20° F. has a relative humidity of only about 7.3% when heated to 70° F.

Under such conditions the body evaporation is so rapid that we get the sensation of cold even though the temperature may be 70° F., which tends to make us overheat our houses. This overheating and the dryness of the nose and throat make us liable to take cold easily.

In hot air furnaces, we use a water pan in the furnace and the water evaporated rises with the hot air into our rooms. In steam and hot water heating the problem is more difficult. Pans of water on top of or behind radiators have very little effect, probably raising the humidity not over 5%. Steam or water sprays in the air have been used to a slight extent but they tend to produce irregular humidification, with too much moisture in some places and not enough in others. The only solution of our problem seems to be a circulation of moist air throughout the rooms. Eventually we shall have large installations in our houses but these are at present too expensive for the ordinary house owner. One of our industrial magazines recently prophesied that within a few years humidification will be a business amounting to $250,000,000 per year.

There will soon be marketed a new domestic humidifier made by the Manufacturers Machine Co. of North Andover, Mass. This firm has had years of experience in making humidifiers for industrial plants. The principle involved in the new humidifier is the same that they use in their large installations. A small electric fan consuming less current than a 40 watt bulb, draws

375 cubic feet of air per minute over 2,000 square inches of water saturated wicking, kept moist by water in which it dips. There is no danger of over humidification for the amount of water evaporated from this wicking will decrease as the humidity rises and a constant humidity of about 50% can be maintained. Moreover the circulation of the air carries this to all parts of the room. This humidifier is designed for living rooms, hospital or school rooms and offices.

In summer, by substituting ice for the wicks, it is possible to not only cool the air, but also to decrease the humidity as the air passing over the ice is cooled below its saturation point and moisture is actually deposited on the ice.

SOME DEVELOPMENTS IN COMMUNICATION.*

BY JOSEPH W. CASSIDY,
New England Telephone and Telegraph Company.

It is indeed a privilege for the New England Telephone and Telegraph Company to contribute in any way to your splendid conference. The general setting of your meeting holds a particular appeal to anyone engaged in the business of electrical communication, a great industry founded squarely on the physical principles first applied practically by an alumnus of this Academy, the inventor of the electrical telegraph, Professor Samuel F. B. Morse, to whose memory this magnificent building is dedicated.

To anyone making a study of the history of the development of communication one fact is immediately apparent; all the great inventors, Morse, Bell, Thompson, Marconi and others who continued their work and added to their achievements sought the advice of the physics teachers of their day. The advice was always willingly given together with hearty encouragement.

The students and teachers of pure science in their laboratories and class rooms, developed the great physical principles which later enabled the inventors to perfect for mankind our present systems of communication.

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*In connection with this address Mr. Cassidy showed two moving pictures, "Far Speaking" and "Television."

In the hour devoted to this portion of your conference I shall talk briefly and shall depend upon two reels of motion pictures to show more clearly and completely than I could hope to do in a talk, two of the most recent developments by Engineers of the Bell System. The first picture will show the workings of transoceanic radio telephony, employing radio as an adjunct to land telephone lines. The other picture will demonstrate television.

May I outline for you in a few minutes the history of the development of communication to serve as a background for the pictures? Due to the time allotted, my remarks will be sketchy and non-technical. Consequently, the names of many deserving men and many important inventions will not be mentioned. Only the most important steps will be outlined.

The telegraph was the forerunner of all our modern methods of electrical communication. Morse opened a new era in the world's history, an era of social and industrial advance exceeding the strongest hopes of the far-seeing inventor.

From the time of the first marathon runner, Phidippides, man's desire to overcome time and distance has given impetus to the development of communication. In early times signal fires on mountain crags were the chief transmitters of human intelligence. Without going into history to recall the sailing ship and stage coach era of communication, or the pony express riders who made such thrilling romance in our own country, let me cite an instance in our national history which indicates the tremendous value of instantaneous communication.

Those of us who recall the incidents surrounding the signing of the peace treaty of Ghent which officially ended the War of 1812, remember how the despatches were carried on fleet horses to the sea coast where they were placed aboard the fastest sailing vessel of the time for transmittal to America; also how two weeks after peace had been arranged, the bloodiest battle of the war was fought at New Orleans, and thousands of men died whose quarrel had already been honorably adjusted.

It was more than two weeks later that a messenger

from the army of General Jackson on the Mississippi arrived at the Octagon House on the Potomac to notify President Madison of the victory.

By contrast with this it took but a few hours in 1918 to notify the entire world that the armistice halting the World War had been signed in Paris.

After the invention of the telegraph, many scientists attempted to devise some means of transmitting human speech over wires. In 1875, Doctor Alexander Graham Bell invented the telephone at Boston. The inventor was at that time Professor of Acoustics and Vocal Physiology in Boston University teaching his father's method of Visible Speech by which deaf mutes were taught to talk. Bell was a teacher by choice and heredity. His grandfather and father had both been teachers. Early in life, when Bell was in London, he became acquainted with Alexander J. Ellis, a young scientist and teacher of note. Ellis introduced Bell to Sir Charles Wheatstone who encouraged him to enter the field of invention. The influence of these two men inspired Bell to attempt the invention of the telephone. Later in life, when Bell reached an impasse in his work on the telephone, he sought the advice of Doctor Joseph S. Henry in Washington. Henry was enthusiastic over Bell's efforts and urged him to continue. Bell said that he lacked the electrical knowledge necessary to do so, whereupon, Doctor Henry told him to get it. Bell redoubled his efforts and succeeded in his work. His next work was to interest the world in his invention. With his last few dollars and some borrowed money he exhibited the telephone at the Centennial Exposition in Philadelphia. For days his exhibit received little attention. Near the close of the Exposition, Emperor Dom Pedro of Brazil who was leaving the Exposition Hall saw Bell, with whose work for deaf mutes he was familiar. He asked Bell what he was showing and was invited to listen to the inventor speak over the telephone. On hearing the voice of his friend in the receiver the Emperor exclaimed, "My God, it talks." Immediately crowds gathered around the baby telephone and it became the talk of the Exposition.

The general public, however, and the press did not

enthuse greatly over the new invention. In a leading English Journal there appeared a learned article giving many reasons why the telephone, although interesting, would be of no practical value. Another editor, less kind, referred to it as another "American humbug."

The world at that time was not accustomed to a succession of amazing mechanical and electrical developments. The following article from the "Outlook" magazine pictures the public mind of that period.

"TIMES HAVE CHANGED"

A Boston newspaper dated sixty-one years ago contains the following news item: "A man about 46 years of age, giving the name of Joshua Coppersmith, has been arrested in New York for attempting to extort funds from ignorant and superstitious people by exhibiting a device which he says will convey the human voice any distance over metallic wires so that it will be heard by the listener at the other end. He calls the instrument a "telephone," which is obviously intended to imitate the word "telegraph" and win the confidence of those who know the success of the latter instrument without understanding the principles on which it is based. Well informed people know that it is impossible to transmit the human voice over wires as may be done with dots and dashes and signals of the Morse Code, and that, were it possible to do so, the thing would be of no practical value. The authorities who apprehended this criminal are to be congratulated, and it is to be hoped that his punishment will be prompt and fitting, that it may serve as an example to other conscienceless schemers who enrich themselves at the expense of their fellow-creatures."

In 1876 the first complete sentence was transmitted from Cambridge to Boston, two miles distant. Four years later, conversations were held between Boston and Providence, R. I., forty-five miles apart. Until 1881 all wires were run on pole lines but that year underground cable was introduced. In 1892, New York and Chicago were connected by telephone. It was then thought that the ultimate in long distance telephony had been reached.

In 1899 Marconi introduced his wireless telegraph.

The same year another Professor, Michael Pupin, introduced the loading coil which permitted the use of smaller wires and extending the range of telephone transmission. In 1911, telephone service was established between New York and Denver, twenty-one hundred miles away.

In 1915, it was my good fortune to listen in Boston to the "Star Spangled Banner" sung in San Francisco, over three thousand miles away, at the official opening of the first transcontinental line. The vacuum tube telephone repeater was first used in connection with this line. That same year speech was transmitted by radio by engineers of the Bell System from Arlington, Virginia, across the continent to San Francisco, over the Pacific to the Hawaiian Islands and across the Atlantic to Paris, France.

In 1921, the United States and Cuba were connected by an undersea telephone cable one hundred and fifteen miles long. That year also, by means of loud speaking telephones and land lines of the American Telephone Company, one hundred and fifty thousand people in Arlington, Virginia, New York and San Francisco heard the Armistice day exercises at the burial of America's Unknown Soldier in the great national cemetery. There is no way of estimating the number of people who in their own homes now listen to such events as the recent funeral exercises of the beloved Knute Rockne broadcast simultaneously from many radio stations all interconnected by land lines of the Bell System.

In 1924, a photograph of President Coolidge was sent over telephone wires from the National Republican Convention at Cleveland to New York City. In 1927, commercial telephone service was inaugurated between the United States and England by means of radio and land telephones lines. This service has since been extended to France, Germany, Holland, Belgium, Spain, Italy, and Austria. Each month some new country is made accessible to American telephone users. On April 1 of this year, service was opened between the United States and Java, East Indies.

In 1927, television was successfully demonstrated by the American Telephone and Telegraph Company.

President Hoover, then Secretary of Commerce, telephoning from Washington was heard and seen clearly in New York City, in fact, seen so clearly that the changing glint of his eyes was discernable.

The teletypewriter, now almost universally in use, enables typists in the offices of the great news-gathering agencies to operate typewriters located in newspaper offices in distant cities.

The Bell Laboratories, employing thousands of skilled scientists, develop many valuable devices. The electrical larynx, an instrument that enables persons to talk whose vocal cords are impaired through disease or injury, is one of their products. The audiometer, another of their inventions, permits physicians to determine accurately hearing defects of patients. Talking moving pictures were also developed in the Bell Laboratories.

Some idea of the present scope of telephone communication may be had from the fact that one can telephone from any of the nineteen million Bell telephones in the United States to any other telephone located in this country and the countries already mentioned.

Many ships at sea can also be reached from these same telephones. Only last summer Captain Yancey, flying six thousand feet above the city of Buenos Aires, telephoned by means of radio and land lines, to the Pilot Radio and Tube Company in Lawrence.

Few of us venture to predict what future developments will be made.

May I leave just one thought with you? There may be some at this conference who in their daily work in class rooms may inspire some student to explore the field of science. This inspiration and encouragement may give to the world inventions as valuable as those of Morse, Bell, Marconi or Carty.

CLASSROOM FILMS.

By George A. Gould, *Eastman Teaching Films, Inc.*

For many years, educators have realized the almost unlimited possibilities of the motion picture for teaching purposes. However, the available equipment had been expensive, cumbersome, complicated to operate and, moreover, there was hardly any matrial that had been prepared especially for teaching. Furthermore, the re-

strictions in nearly every state in the union made it necessary to have not only a licensed operator but a fire-proof booth or a heavy, completely enclosed projector. In other words, the inconvenience attending the wide-spread use of such equipment prevented the large producers of motion pictures from risking much money in a field with which they were sadly unfamiliar.

With the advent of the 16 mm. non-inflammable film—and its world-wide adoption as a standard width—the present day classroom film became possible, even inevitable. Its advantages were obvious, as educators were quick to perceive.

First, the initial cost was vastly lower, both for projectors and for films. The equipment was not only easily portable but extremely simple to operate. Furthermore, there were no restrictions, *anywhere* against its use; there was no increase in insurance rates; no fire-proof booth nor any licensed operator necessary, mainly because there is no known producer of raw film using anything but NON-INFLAMMABLE stock for the 16 mm. width. Remove the fire hazzard and all restrictions vanish.

The 16 mm. film lent itself perfectly to the production of films to be used where they *should* be used in teaching—namely, in the classroom. Their relatively low cost and surprisingly long life permit them to be used on the spot—on the day when you wish to drive home the telling points of the subject immediately at hand—not a week after you have studied that subject—or a month before—or at any time the rental agency can get the film back from someone else to send to you. By owning your own films, they are available WHEN you need them, for AS LONG as you need them and for as many times as you wish to show them, either as a whole or by sections.

Mr. Gould showed two films, "Behavior of Light" and "Four Stroke-Cycle Gas Engine" which were very enthusiastically received.

THE NEW PHYSICS AND THE SECONDARY SCHOOL.

By Prof. E. C. Kemble, *Harvard University.*

Professor Kemble identified the "new physics" with the new quantum theory. He characterized it as a revolution in thought based on hard experimental facts which seems paradoxical because it substitutes unfamiliar basic concepts for familiar ones. The new theory is a purely descriptive mathematical formulation of the fundamental laws of nature very far removed from the model-seeking thought formerly so universal in physics. It is statistical and hence indeterministic. Such a theory is, of course, repugnant to many minds, but the answer to all objections lies in the extraordinary power of the modern quantum mechanics to deal with problems far beyond the scope of its "classical" predecessors.

The new physics is from its nature unsuited to direct secondary school instruction since pupils must inevitably begin at the beginning and cannot be carried far in a single year. In fact it seems unwise in most cases at present to attempt to give college undergraduates more than a survey of the fundamental experimental facts on which the quantum theory is based. On the other hand, the secondary school pupil should be informed, no doubt, that light has some of the properties of energy corpuscles as well as some of the properties of wave motion, and he should be taught the classical

mechanics as an approximate theory adequate for the description of the motions of large scale bodies, but admittedly inadequate for atomic and sub-atomic motions. Too much attention to conclusions based on advanced research is to be deprecated as confusing, but an occasional glimpse of the problems and results of the new physics will surely be stimulating to interest and imagination.

The most important connection between the new physics and secondary school teaching is probably the indirect effect which study of the quantum theory should have on the mental attitude of all teachers of elementary physics toward their work. We should all relearn the necessity of approaching nature with an open mind, sharply differentiating theory from fact, and following the evidence wherever it leads without regard to our preconceptions. Physics taught in this spirit, whether in school or college, will be the truly cultural subject which it ought to be.

The last address was by Dr. Alfred V. Kidder of the Carnegie Institution. He spoke upon the Indians of North America and the Mayan Civilization. The talk was somewhat informal and illustrated profusely with beautiful lantern slides. Dr. Kidder told in detail of the restoration of some of the Mayan Temples and with his first hand knowledge gave us a most interesting insight into the trials and triumphs of this branch of historical research. The Secretary regrets that it is not possible to publish the address in full.

WILLIAM W. OBEAR, *Secretary.*

A PRELIMINARY STUDY ON THE DIFFICULTY OF CERTAIN CHEMISTRY TOPICS.

BY ALFRED M. EWING,

Ohio Northern University, Ada, Ohio, and
GEORGE T. RANKIN.

The authors wondered if some of the chemistry topics that are usually presented to high school and freshman college students could be rated according to their degree of difficulty in understanding; and also if the topics ranked in the same order according to their degree of difficulty in presentation. Further, whether the boys would rate the topics the same as the girls, and the high school students the same as the college students.

In order to ascertain the ratings twenty topics were submitted to more than five thousand high school and freshman college students of chemistry in seventy different schools. The students were asked to rate the topics according to the degree of difficulty they had in understanding them, and the teacher was asked to rate the same topics in the order of difficulty in presentation to students.

The topics were divided into two groups. The first group consisted of fundamental ideas and theories of a broad character upon which the science of chemistry is built. The second group contained topics of useful ideas of a more specific nature that support the general topics in Group I. It was impossible to make a clear cut distinction between the groups, or to group, word, and select the topics in such a way that everyone should agree.

The following are the groups of topics that were submitted.

GROUP I

1. The Theory of Ionization; Electrolysis.
2. The Atomic and Molecular Structure of Matter; The Role of the Electron in the Structure of Matter.
3. Avogadro's Principle.
4. Atomic Weights; Molecular Weights; Combining Weights; Equivalent Weights.
5. The Kinetic Molecular Theory of Gases.
6. Dalton's Atomic Theory; Laws of Definite and Multiple Proportions.
7. The Chapter of Organic Chemistry found in Inorganic Text Books.
8. Equilibrium; Law of Mass Action.

GROUP II

1. Why do 22.4 liters of any gas equal one gram mol?
2. The Idea of Valence.
3. Why is oxygen taken as 16 for a standard of atomic weights?
4. The Periodic Law; The Periodic Table; Isotopes.
5. Atomic Numbers.
6. The Gas Laws (Boyle's, Charles', Bay-Lussac).
7. The Electrochemical Series.
8. Calculations of Problems; (a) from combining weights; (b) from equations; (c) problems involving the gas laws; (d) percentage composition problems.
9. Hydrolysis.
10. Oxidation and Reduction of Elements.
11. Formulas; How to Write and Balance Equations.
12. X-Ray Spectra; Spectroscope; Spectrum Analysis.

The data taken from the lists submitted were summarized in tables according to the following classes: college teachers, high school teachers, college students, high school students, college boys, high school boys, college girls and high school girls. From these tables of summaries the topics were ranked by two methods, and their ranks tabulated for purposes of comparison.

This survey seems to indicate that the topics cannot be rated according to their degree of difficulty in understanding, or according to their degree of difficulty in presentation to a great degree of accuracy. However, when the ranks were selected from the data obtained and then compared, it was found that the ranks for difficulty in understanding and presentation agreed on 40 per cent of all the topics in college and 63 per cent in high school; provided, however, one assumes that a difference of one in the ratings of a topic does not constitute a disagreement. If a difference of two does not constitute a disagreement then the agreement is 55 per cent in college and 87 per cent in high school.

This survey appears to indicate that more stress should be placed on the mathematics of chemistry and the relation of the Periodic Law and the Periodic Table to chemistry. This means that more stress should be placed on the understanding of chemistry.

The survey shows that as a general rule the topics that are difficult for the teachers are also difficult for the students. The remedy is obvious.

SOME OBSERVATIONS OF FORESTRY PRACTICED IN FRANCE AND ITALY

By WORRALLO WHITNEY, BOTANY EDITOR.

While on a tour through some parts of Europe last Spring, we were especially interested in the methods used in these countries to eke out their scanty supply of wood. In the timbered parts of the United States we see everywhere small wood lots, usually tiny remnants of the once universal forest which covered the country, or second growth timber crops of the original forest. We saw nothing corresponding to these small farm wood lots in Europe. There are, of course, so-called forests, but they are either timber growths on lands unfit for cultivation for agriculture or municipal forests owned by towns or cities.

The method by which the small landowners make up for this absence of farm lot forests is quite interesting and unique. As we traveled through the country in early Spring before the leaves were out on the trees we had a favorable opportunity for our observations. In this country the farmers do not as a rule allow hedgerows to grow nor allow trees in these hedgerow boundaries of fields and farms to become large, because the trees are likely to shade the crops and rob the surrounding soil of moisture and fertility. In fact it is considered a mark of bad farming to allow bushes and trees to grow along boundary fences. In France and Italy the practice in this respect is quite contrary to the practice in this country. Instead of discouraging fence row growths, the growth, especially of trees, is encouraged and all field boundaries are marked conspicuously by rows of tall trees; the trees a rod to two or three rods apart. As the fields and farms are very small, this means the growth of a good many trees.

No side branches are allowed to grow on the trees and in early Spring, when we saw them, the trees resembled tall poles, often fifty feet or more in height. The trimming is done annually during the winter and as the trees sprout profusely from bottom to top, there are large quantities of twigs to cut off. These twigs are all saved, tied up in bundles about the size of grain bundles and hauled to the homestead where they are used, presumably, largely for fuel,

but many of the trees are willow and their twigs are usable for basket making.

This use of fence row trees serves, evidently, the purpose of supplying the farmers with a supply of cheap fuel and small timber for various purposes. By thus trimming the trees of long side branches the difficulty of shading the crops is avoided and the smaller top growth will certainly draw much less from the soil of the adjoining fields in the line of moisture and soil fertility. This practice of utilizing fence row growth is not followed in England. We concluded that this was due to the relative cheapness of coal in this country. In England the large bodies of coal comparatively near at hand, no doubt, make the practice of foresting the fence rows unprofitable.

In Italy we observed another forestry utilization method still more unique than that practiced in France. Vineyards are universal in Italy, in the valleys and on the hillsides. But on some of the rich bottom lands of central Italy a very interesting method is followed in utilizing all available sources of income. Here trees are used in place of stakes to support the vines. The vines are planted at the base of the trees which are planted in rows fifty or more feet apart. The vines are trained up the trees and at about eight or ten feet from the ground wires stretched between the trees carry the vines laterally between the rows and between the trees in the row. The vines are thus high enough from the ground to allow the cultivation of the soil beneath to proceed freely. The trees have all their side branches trimmed off annually but are not restricted in height. The vines which grow between the rows are not thick enough to shade the ground deleteriously. Thus the vineyardist harvests three crops from these fields, the fuel trimmings from the trees, the grapes from the vines and a grain or other crop from the ground between the rows. This seems a striking example of the utilization of every resource possible practiced in these European countries.

Education alone can conduct us to that enjoyment which is at once best in quality and infinite in quantity.—Horace Mann.

THE RHIND MATHEMATICAL PAPYRUS.

By H. E. SLAUGHT.

A high school student of mathematics, whenever he begins to think things through for himself, must at some time wonder how the human race learned to count and how arithmetic and algebra came to fill so important a place in the affairs of men. There are few chapters in ancient or modern history dealing with peaceful methods of upbuilding civilization that are as pathetic and even tragic as the struggle of mankind to build a number system adequate for the solution of the world's problems.

The Rhind Mathematical Papyrus is a document written by an Egyptian priest between three and four thousand years ago, which shows one stage (the oldest on record) of that struggle of men to think in terms of numbers. This Papyrus is preserved in the British Museum where very few, if any, of our high school boys and girls would ever be likely to see it, and even if they did it would not be possible for them to decipher the writing which is in Egyptian hieratic symbols. But fortunately it has been photographed and translated so that any one interested can see just how it looks in its original form and can compare the hieroglyphic writing with both the literal and the free translation in English. The Papyrus is about 18 feet long and 13 inches wide and is reproduced in 31 photographic plates together with 109 fac-simile plates each showing a small portion magnified so as to bring out clearly both the original handwriting of the priest who transcribed it and the corresponding transliteration in the more common hieroglyphic form. On the pages opposite these 109 plates are explanatory notes and a complete literal translation in English. All these plates are bound in a massive volume ten by fourteen inches in size. A second volume contains a wealth of descriptive matter, an extensive bibliography of Egyptian mathematics, and a free translation of the whole papyrus.

A study of this document by high school students of mathematics will not only be a revelation of the difficulties encountered by mankind in developing arithmetic and algebra, but it will also furnish a most interesting exercise for members of a school Mathematics Club to work out the Egyptian method of solution of some of the problems and compare this with our present day algebraic methods. This will develop a wholesome appreciation of what has been accomplished in mathematics since this earliest known textbook was compiled some 3600 years ago.

It is my belief that it is well worth while for all students of algebra (and arithmetic) to have access to these volumes, but it may require a little careful planning to make this possible, since the present price of the set is $20.00 (an amount far below the actual cost of preparation and printing). However, I believe it can be done in one of the three following ways:

(1) In a city having two or more high schools, let the mathematics teachers petition the Board of Education to purchase the set, keep it at headquarters, and loan it out for a specified time to each school during each year. In case there is only one high school in the system it then could be kept in the school library. If there are several high schools, more than one set may be needed.

(2) If this petition fails, try to make an arrangement with the public library so that pupils could have access to these volumes in some private room or reference room.

(3) If both these plans fail, then the Mathematics Club can surely devise means whereby the money can be raised. It may be by some entertainment or by direct contributions to a book fund or a class might present the set to the school library as a memorial. There are numerous mathematical plays which have been published from time to time. One of these might be elaborated and presented to the whole school with a small admission fee. Something can be done if the problem is tackled in earnest.

There is one admonition, however, which should be faced. The edition of the Papyrus sets was limited to 600 and a large number of these have been sold. When this edition is exhausted no more can be had. Furthermore, as they become scarce the demand will increase and the price will be advanced—as is usual in such cases. In fact, the price is likely to be raised to $25.00 on January 1, 1932. Hence action should be taken at once by those who wish to take advantage of the present price of $20.00.

The Papyrus was published under the auspices of the Mathematical Association of America but is distributed to non-members of this Association by the Open Court Publishing Company, 337 East Chicago Avenue, Chicago, Illinois.

SCIENCE QUESTIONS.

A Column of Co-operation in a Magazine of Co-operation.
Conducted by Franklin T. Jones, 10109 Wilbur Avenue, Cleveland, Ohio.

Co-operation is the **process** of **Give and Take.** What can you give? What would you like to take? Please help to make this a real **Department of Co-operation.**

THE ETERNAL QUESTION.

WHAT SHALL WE DO THIS YEAR?
Suggestions, please. Thanks! The Editor.

EDISON'S QUESTIONS.

541.—In November, 1930, SCHOOL SCIENCE AND MATHEMATICS published the QUESTION EDISON PUTS TO BOYS AFTER HIS JOB.

Suggestion—Try them on your classes at the *beginning* of this year *before* they have studied Physics or Chemistry and again near the *close* of the year *after* they have studied the subjects for a few months.

SCIENCE QUESTIONS Department will be glad to publish your results, comments and questions. Write in results to the EDITOR.

581. What "Thought Provokers" have you? L. Paul Miller sends in the following. Try them on your pupils *early*. Please report results.

"THOUGHT PROVOKERS"

From L. Paul Miller, Central High School, Scranton, Pa
SENIOR B CHEMISTRY, Entrance Test (used first day).

1. How could you find out whether air is necessary for wood to burn?
2. How could you find out what things are produced when wood burns?
3. How could you prove what gas in the air is used when something burns?

4. If you heat potassium chlorate ($KClO_3$) oxygen gas is given off, and potassium chloride (KCl) is left. How could you find, most accurately, the weight of oxygen given off when any certain weight of potassium chlorate is heated?

5. If you were told that soap acts differently in hard water and in soft water, but not how it acts, how could you find out whether Scranton's water is hard or soft?

6. When two thousand pounds of coal have been burned in your furnace, about two hundred pounds of ashes are left. What has become of the other eighteen hundred pounds of matter?

7. If you put a white powder in water, and the mixture remains white, how could you find out whether or not any of the white powder dissolved in the water?

8. If you were given a mixture of sulphur and sugar, how could you separate these two substances?

9. In what two ways could you prove that water is a compound of hydrogen and oxygen?

10. If you find that household ammonia (NH_4OH) turns litmus paper blue, and that some unknown liquid turns a piece of litmus paper blue, what conclusions can you come to, as to what the unknown liquid is?

582. *An Aim for 1931-1932*—What do you think of looking forward to an Examination like this at the close of your school year?

The University of the State of New York, 251st High School Examination.

CHEMISTRY

Wednesday, June 17, 1931—1:15 to 4:15 p. m., only.

Write at top of first page of answer paper (a) name of school where you have studied, (b) number of weeks and recitations a week in chemistry, with the total number of laboratory periods and the length of such periods. A paper lacking the statement of laboratory work will not be accepted at a standing of less than 75 credits.

The minimum time requirement is five recitations a week for a school year.

An unprepared laboratory exercise of two periods counts in place of one recitation. At least 30 laboratory exercises are required.

Answer any 10 questions. Answers should be numbered and lettered to correspond with the questions.

1. *a.* Using a labeled diagram, describe the laboratory preparation of oxygen. [6]
   b. Write the chemical equation for the reaction. [2]
   c. Give *two* ways in which oxygen is used. [2]
2. Complete *five* of the following, using names and formulas: [10]
   a. sodium hydroxide + sulphuric acid —— >
   b. nitric acid + calcium hydroxide —— >
   c. water + sodium —— >
   d. aluminum hydroxide + sulphuric acid —— >
   e. ammonia gas + water —— >
   f. hydrogen sulphide + copper sulphate —— >
3. How would you distinguish *(a)* sodium carbonate from sodium hydroxide [2], *(b)* white lead from zinc oxide [2], *(c)* manganese dioxide from charcoal [2], *(d)* iodine from graphite [2], *(e)* sandstone from limestone [2]?
4. In accordance with the electron theory state the difference between a metal and a nonmetal [2]. Make a diagram to illustrate a possible structure of the atom of the element having the atomic number 12 [4]. State *two* properties this element has in common with the element whose atomic number is 20 [4].
5. *a.* Starting with the metal calcium, show by means of an

equation the formation of a base. [2]

b. Starting with the nonmetal sulphur, show by means of equations the formation of an acid. [4]

c. Using this base and acid, write a balanced equation. [2]

d. Why does the reaction expressed by the equation in *c* proceed to an end? [2]

6. Name the constituents of five common alloys and state one use of each alloy. [10]

7. The following scientists have made distinct contributions to chemistry: Priestly, Lavoisier, Dalton, Moseley, Mendelejeff, Madame Curie.

a. State *one* important contribution of each of *four* of these scientists. [8]

b Name *two* of these scientists who have made most of their contributions during the 20th century. [2]

8. Explain *each* of the following: [10]

a. A bottle of ammonium hydroxide near a bottle of concentrated hydrochloric acid became coated with a white solid.

b. Sulphuric acid should be poured into water rather than water into sulphuric acid.

c. A bottle filled with concentrated sulphuric acid overflows on standing exposed to the air.

d. Solution of silver nitrate is usually kept in brown bottles.

e. Salt in the salt shaker sometimes becomes "sticky."

9. Answer *two* of the following: [Atomic weights: Ca=40, S=32, O=16, Na=23, Cl=35.5, Al=27]

a What is the percentage of water in crystallized calcium sulphate ($CaSO_4 2\ H_2O$? [5]

b. How many liters of oxygen are needed for the complete combustion of 10 liters of acetylene (C_2H_2)? [5]

c. How many grams of NaCl are required to react with 196 grams of H_2SO_4? [5]

10. Answer *two* of the following: [See question 9 for atomic weighs.]

a. What weight of aluminum may be obtained from 1000 grams of aluminum oxide (Al_2O_3)? [5]

b. How many liters are contained in a volume of oxygen gas that weighs 143 grams at standard conditions? [5]

c. How many liters of hydrogen chloride gase will be obtained from 10 liters of chlorine when combined chemically with hydrogen? [5]

11. *a.* Explain why the water in some localities is more suited for laundry purposes than the water in other localities. [3]

b By what chemical means may water be made fit for laundry laundry? [3]

c. Write the chemical equation for your answer to *b.* [4]

12. The following are factors usually associated with the scientific method: open-mindedness, love of truth, holding judgment in abeyance until all possible data are collected, lack of prejudice, correlation of fact and theory. With these factors in mind, answer either *a* or *b* [10]

a Compare the method of winning a high school debate with the method used in a laboratory experiment.

b Compare the method of Priestly with that of Lavoisier.

13. The following formulas represent useful compounds:

$LiCl$, $AgNO_3$, Na_3PO_4, $BaCO_3$, Bi_2O_3

In the space at the right of *each* of the following names write the formula of the compound: [10]

Barium phosphate.....

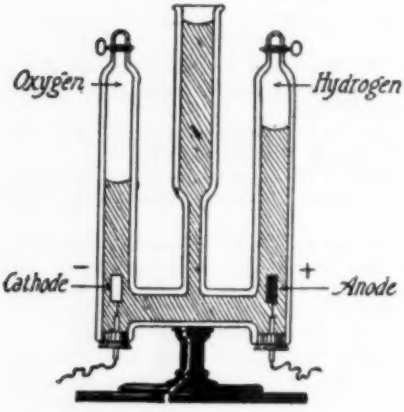
Silver carbonate.....

Lithium nitrate.....

Bismuth chloride.....
Sodium oxide.....

14. Complete the following table by supplying in the proper spaces the names, formulas and uses of the substances represented by the following common names: [10]

Common Name	*Chemical Name*	*Formula*	*Use*
lye			
slaked lime			
muriatic acid			
baking soda			
marble			
Epsom salts			
grain alcohol			
quicksilver			
dry ice			
plaster of Paris			



15. The accompanying diagram, which is incorrect, was made by a pupil on his laboratory experiment sheet to illustrate the electrolysis of water. Answer *a* and *b* with reference to this diagram.

a. Point out *two* errors in the drawing.

(1) .....
..... [4]

(2) .....
..... [4]

b. Write the equation for the reaction. [2]

.....
.....

16. In *each* group at the right underline the *two* terms that are most closely associated with the word at the left. [10]

refrigeration	hydrogen, carbon monoxide, nitrogen dioxide, ammonia, sulphur dioxide
indicator	cupric oxide, litmus, ether, phenolphthalein, mercury
carbohydrate	dextrose, beef fat, cellulose, soap, nitroglycerine

hydrocarbon	coal, methane, producer gas, gasoline, alcohol
fertilizer	sodium nitrate, calcium chloride, potassium chlorate, calcium phosphate, barium chloride
welding	nitrogen, methane, acetylene, water gas, oxygen
bleaching	carbon disulphide, sulphuric acid, chlorine, carbon tetrachloride, sulphur dioxide
abrasive	graphite, carborundum, emery, hard coal, calcium carbide
electrolyte	sulphuric acid, solution of sugar, solution of salt, dilute alcohol, glycerine
fire extinguishers	potassium nitrate, calcium sulphate, carbon tetrachloride, ammonium chloride, sodium hydrogen carbonate

ANSWERS TO CORRESPONDENTS.

568. *From Miss Ernestine M. J. Long, 1618 Quendo Avenue, St. Louis, Mo., U. S. A., in answer to the request from Mr. Lorens Carlsson, Malmo, Sweden.*

"Having read the letter from Mr. Carlsson, I should be delighted to inform him of the methods used in our high school in the teaching of Physics. My curriculum in Physics and Chemistry was made under the supervision and guidance of Dr. Downing of Chicago University."

574. *Question on literature concerning the "Steam Engine." Answer by J. C. Packard, Brookline, Mass.*

Mr. J. H. Rusterholtz, Plattsburg State Normal School, will please call to the attention of Miss Dugan.

In reply to question 574 please say to Miss Agnes H. Dugan that a volume of 514 pages entitled "Lives of Boulton and Watt" by Samuel Smiles, published by John Murray, Albemarle Street, London in 1865—a copy of which lies on my desk—is full of interesting material. She may be able to find a copy in her city library. If the young lady will write to the Watt and Boulton at Soho, England, which was still doing business on the old spot the last I knew, she will be likely to receive further valuable information concerning the original Watt engine.

ATTENTION—*M. Ginat, Professor of Physics, Lycée, Havre, France.*

Please let us have your criticisms and suggestions concerning translation of Besancon Examinations. Please send more examination papers and May, 1930, number of L' ENSEIGNEMENT SCIENTIFIQUE. Thanks! F. T. Jones.

583. *Wanted—Materials for a Machine Shop Course.—C. F. Fitz, West Junior High School, Lancaster, Pa.*

"I have charge of the General Metal Shop of the West Jr. High School of Lancaster, Pa., and next September we are going to start a Unit Trade School. I wonder if it would be possible for me to receive a complete copy of your Machine Shop course and any blue prints or job sheets that are used in connection with it, as I feel that this will be quite a help to us in working up our course of study. If it is possible for me to receive same please quote me the price. Thanking you for your cooperation in our work."

HOW FAST?

584. Major Doolittle takes a Little Jaunt.

As I write this (September 4, 1931), the radio says that Major

Doolittle started this morning from Los Angeles, reached the National Air Races at Cleveland in the afternoon for a late lunch (winning the long end of a $15,000 prize), and went on to New Jersey (winning an additional $2,500). He has just returned to Cleveland for supper with Mrs. Doolittle and Jimmie, Jr., but must set out for St. Louis where he has an engagement tomorrow morning. He broke the records. How fast did he go?

WHAT'S INTERESTING IN SCIENCE ANYWAY!

PROBLEM DEPARTMENT.

CONDUCTED BY G. H. JAMISON,
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor, should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SPECIAL NOTICE.

Please observe that the Editorship of the problem department has changed. All communications relating to this department should go to the new Editor.

LATE SOLUTIONS.

1119, 1181. *W. E. Buker, Leetsdale, Pa.*
1158-60 and **1162-64.** *Lu Chin-Shih, Soochow, China.*

SOLUTIONS OF PROBLEMS.

Editor. Persons sending in solutions should read carefully the instructions about the form of the solutions and the ink-drawn figures. Many times, a good solution is received, but poorly arranged and no India-ink figure given.

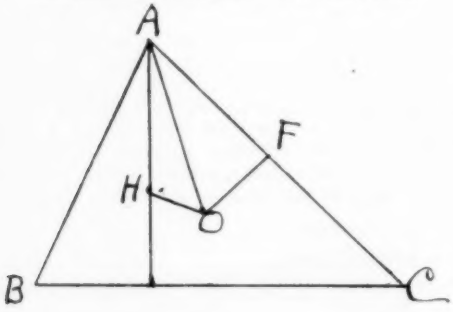
SOLUTIONS OF PROBLEMS.

1169. *Proposed by Norman Anning, University of Michigan.*

Show that a proof of 1142, page 951, November issue, can be obtained from a study of an expression for the distance between the orthocenter and circumcenter of a triangle.

Note. Problem 1142 is: If A, B, and C are the angles of a plane triangle, prove that $\text{Cos A Cos B Cos C} \leq \frac{1}{8}$.

Solution by P. Drohan, Toronto, Ont.



H is orthocenter
O is circumcenter
$OA = R$
$AH = 2R \text{ Cos A}$
$HAB = 90° - \angle B$
$\angle OAC = 90° - \angle B$
$\therefore HAO = A - 2(90° - B)$
$= A + 2B - 180°$
$= B - C$

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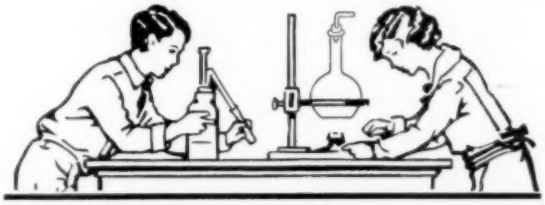

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From Law of Cosines, in $\triangle$ AOH

$$(OH)^2=(AO)^2+(AH)^2-2(OA)\ (AH)\ \text{Cos}\ (C\text{-}B)$$
$$=R^2+4R^2\text{Cos}^2A-4R^2\text{Cos}\ A\ \text{Cos}(C\text{-}B)$$
$$=R^2\left[1+4\ \text{Cos}\ A\left\{\text{Cos}\ A-\text{Cos}\ (C\text{-}B)\right\}\right]$$
$$=R^2\left[1-4\ \text{Cos}\ A\left\{\text{Cos}\ (B+C)+\text{Cos}\ (C\text{-}B)\right\}\right]$$
$$=R^2[1-8\ \text{Cos}\ A\ \text{Cos}\ B\ \text{Cos}\ C]$$

Now $\left(\frac{OH}{R}\right)^2=1-8\ \text{Cos}\ A\ \text{Cos}\ B\ \text{Cos}\ C$, which must be 0 or positive.

Then $\text{Cos}\ A\ \text{Cos}\ B\ \text{Cos}\ C\leq\frac{1}{8}$.

Also *solved by Albert Schwartz, Perth Amboy, N. J.*, and *the proposer.*

1170. *Proposed by a Reader, East Orange, N. J.*

Show that six times the sum of the eleventh powers of the first N whole numbers is exactly divisible by the sum of the cubes of those numbers.

Solved by Albert Schwartz, Perth Amboy, N. J.

Substituting in Bernouelli's equation,

$$Sn=\frac{n^{n+1}}{n+1}+\frac{n^n}{2}+B_1\frac{n}{\angle 2}n^{n-1}-B_2\frac{n(n-1)(n-2)}{\angle 4}n^{n-3}$$
$$+B_3\frac{n(n-1)\ (n-2)\ (n-3)\ (n-4)}{\angle 6}n^{n-5}+\ldots\ldots\ldots\ldots$$

where Sn denotes sum of nth powers of first n whole numbers, and B_1 B_2, B_3 are the Bernouelli numbers, with

$B_1=1/6$ $B_2=1/30$ $B_3=1/42$ $B_7=1/30$ $B_9=5/66$,

we get

(1) $S_{11}=\frac{n^{12}}{12}+\frac{n^{11}}{2}+\frac{11n^{10}}{12}-\frac{11n^8}{8}+\frac{11n^6}{6}-\frac{11n^4}{8}+\frac{5\ n^2}{12}$, which

by factoring is $\frac{n^2}{24}(n+1)^2\ (2n^8+8n^7+4n^6-16n^5-5n^4+26n^3-3n^2-20n+10)$.

(2) $S^2=\frac{n^2(n+1)^2}{4}$

Multiplying (1) by 6 and dividing by (2) we get

$\frac{6S_{11}}{S_2}=2n^8+8n^7+4n^6-16n^5-5n^4+26n^3-3n^2-20n+10$.

Hence S_2 is a factor of S_{11}.

Also *solved by P. Drohan, Toronto, Ont. W. E. Buker, Leetsdale, Pa.* and *Lewis R. Chase, Newport, R. I.*

Note: In the solution submitted by Lewis R. Chase, reference is made to Smith's source book in Mathematics for an account of the Bernouelli equations. Mr. Chase gives the following values of these formulae in factored form:

$S_1=(1/2)n(n+1)$ $S_2=(1/6)n(n+1)\ (2n+1)$ $S_3=(1/4)n^2(n+1)^2$

$S_4=(1/30)n(n+1)\ (2n+1)\ (3n^2+3n-1)$

$S_5=(1/12)n^2(n+1)^2(2n^2+2n-1)$

$S_6=(1/42)n(n+1)\ (2n+1)\ (3n^4+6n^3-3n+1)$

$S_7=(1/24)n^2(n+1)^2(3n^4+6n^3-n^2-4n+2)$

$S_8=(1/90)n(n+1)\ (2n+1)\ (5n^6+15n^5+5n^4-15n^3-n^2+9n-3)$

$S_9=(1/60)n^2(n+1)^2(6n^6+18n^5+3n^4-24n^3+3n^2+18n-9)$

$S_{10}=(1/66)n(n+1)\ (2n+1)\ (3n^8+12n^7+8n^6-18n^5-10n^4+24n^3+2n^2-15n+5)$

$S_{11}=(1/24)n^2(n+1)^2(2n^8+8n^7+4n^6-16n^5-5n^4+26n^3-3n^2-20n+10)$

1171. *Proposed by Lewis R. Chase, Newport, R. I.*

Point O lies outside the straight line ABCD. AO = 100 ft., OD = 125 ft.,

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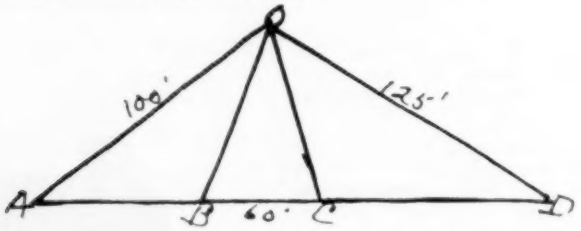
and BC = 60 ft. $\angle AOC = \angle BOD = 90°$. Find the length of AD.

Solution by P. Drohan, Toronto, Ont.



Since $\angle AOC$ and $\angle BOD$ are right angles the circles circumscribing $\triangle AOC$ and $\triangle BOD$ intersect in 0 and AD is the line of centers. $\therefore OB$ must equal OC and the perpendicular from 0 on BC bisects the segment BC. Hence we have the relations

$100^2 = (AB+30)\ (AB+60)$; $125^2 = (DC+30)\ (DC+60)$

or $10000 = AB^2+90AB+1800$; $15625 = DC^2+90DC+1800$

or $AB^2+90AB-8200 = 0$; $DC^2+90DC-13825 = 0$

$\therefore AB = 56.12$

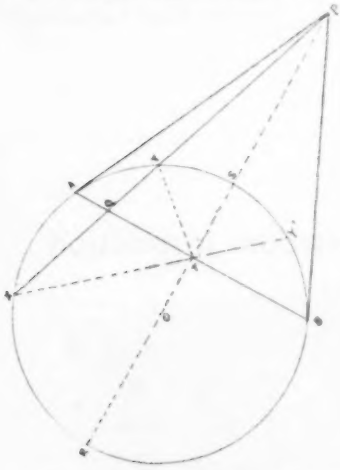
Similarly $DC = 80.90$

$\therefore AD = 56.12+60+80.90 = 197.02$

Also *solved by Proposer.*

1172. *Proposed by I. N. Warner, Platteville, Wis.*

If from the same point a secant and two tangents be drawn to a circle, then the secant will be divided harmonically by the circumference and the chord joining the points of tangency.



Solution by W. E. Buker, Leetsdale, Pa.

By similar triangles, $\overline{OA}^2 = \overline{OS}^2 = OT \cdot OP$. Then, by a familiar theorem, (RSTP) is a harmonic range. Also, X(RSTP) is a harmonic pencil. Since XR and XS are orthogonal, XS bisects angle TXY.

(If a pair of conjugate rays of a harmonic pencil is orthogonal, these rays are the bisectors of the angles formed by the other two rays of the pencil.)

Hence, arc ys = arc $y's$.

Now, TS bisects angle $y'Ty'$ and since AT is orthogonal to TS, AT bisects the supplementary angle $y'TX$.

Therefore, the bisectors TA and TS of the interior and exterior angles of triangle XTy divide the secant PX harmonically.

Also *solved by R. T. McGregor, Elk Grove, Cal.; P. Drohan, Toronto, Ont.; W. E. Batzler, Battle Creek, Mich.,* and *Lewis R. Chase, Newport, R. I.*

1173. *Proposed by W. E. Buker, Leetsdale, Pa.*

Right triangles A, B, and C, all sides integral, have equal areas. Find the values of the sides of the triangles.

Solution by the Proposer.

Let the sides of the triangle be p^2-q^2 and 2pq, while the hypotenuse is p^2+q^2. The area of the triangle is $pq(p^2-q^2)$. The problem resolves itself into finding three pairs of values of p and q in integers for which $p^3q-pq^3 = c$.

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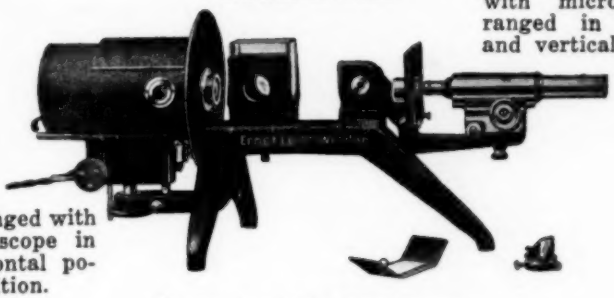

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$q=m^2-n^2$
$p=m^2+mn+n^2$
$q=2mn+n^2$
$p=m^2+2mn$
$q=m^2+mn+n^2$

The value of c derived for each of these pairs of values is $mn(m-n)(m+n)(m+2n)(2m+n)(m^2+mn+n^2)$

To find the sides of the triangles, it is simply necessary to assign integral values for m and n $(m \neq n)$ and find values of p^2+q^2, p^2-q^2 and $2pq$, which are the sides of the required triangles.

Some solutions follow:

A	B	C
42	40	58
70	24	74
112	15	113
208	105	233
182	120	218
380	56	394
190	336	386
608	105	617
798	80	802

It is readily seen that the method is capable of being continued indefinitely, and that there are an infinite number of triangles satisfying the conditions of the problem.

1174. *Proposed by Guy C. Lentini, Boston, Mass.*

A concern manufactures a mechanical appliance in 8 sizes. The price list, which is changed once a year, is always arranged so that the price bears a linear relation to size. Which buyers were not affected by the price changed for 1930 if the value of the smallest machine rose four dollars and that of the largest fell ten dollars?

Solution by J. Ross Adams, Cape Girardeau, Mo.

Let P = price

Let S = size

Let $P=A+MS$, be the price equation for 1929, where A and M are constants.

If $S_1=1$, then $P_1=A+M+4$

If $S_2=8$, then $P_2=A+8M-10$

The equation for the 1930 price is (using the two-point form):

$$P=A+6+MS-2S$$

Solving the 1930 and 1929 price equations, it is seen that $S=3$. Hence the buyers of the 3rd size were unaffected by the price change.

Also *solved by Frances Ellen Baker, Creston, Iowa.*

THIS IS APPRECIATED.

Recently in a set of examinations for teachers the applicants were asked to name some professional books of value to them. One reply was that more help had been received from SCHOOL SCIENCE AND MATHEMATICS than any other source. The problem department was also mentioned.

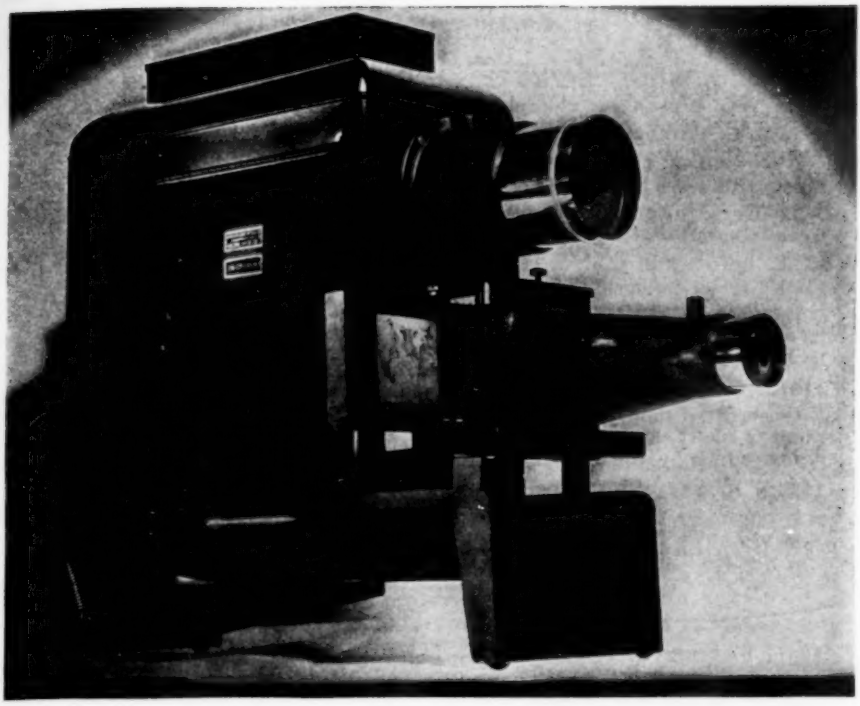
PROBLEMS FOR SOLUTION.

1187. *Proposed by Merton Cuthbert, Los Angeles, California.*

If two triangles have two sides of one equal to two sides of the other, prove that the greater included angle has the shorter bisector.

1188. *Proposed by Greeta Gibson, Iowa City, Iowa.*

Find the locus of a point, P, on a line of constant length that moves



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so that its extremities, A and B, are on the X and Y axes respectively. The point, P, is at the distance a from A, and the distance b from B.

1189. *Proposed by P. Drohan, Toronto, Ont.*

To divide the area of a circle into n equal parts by lines drawn parallel to a diameter; similarly to divide the volume of a sphere by planes drawn parallel to a plane passing through the center.

1190. *Proposed by Walter H. Carnahan, Indianapolis, Ind.*

By use of the Theorem of Menelaus (The Converse) prove that the feet of the perpendiculars dropped upon the sides of a triangle from any point on the circumcenter are collinear.

1191. *Proposed by Guy C. Lentini, Boston, Mass.*

O is a fixed point and P any point on a fixed circle; on OP is taken a point Q such that OQ is in constant ratio to OP; prove that the locus of Q is a circle. (Taken from Loney's Corordinate Geometry.)

1192. *Proposed by S. Chuang, Shausi, China.*

Solve this set of equations:

$$X^2 - Y^2 = XY - 1$$
$$X^3 + Y^3 = X^2Y^2 - 1$$

BOOK REVIEWS.

Plane and Solid Geometry, by Joseph P. McCormack, head of the Department of Mathematics in the Theodore Roosevelt High School, New York City. Pages xii+541. 1931. D. Appleton and Company, New York.

This book treats plane and solid geometry separately. It is well organized and very attractive. The illustrations are numerous and very well drawn. The body of the text contains propositions that constitute a minimum course and supplementary materials are added which offer opportunity for wide selection.

Emphasis is placed upon exercises rather than upon the formal proposition. These exercises are made up of class exercises, optional exercises, honor work, and applied problems. Since there are a large number of exercises, complete proofs are given for all important propositions without the danger that pupils will be apt to memorize.

Other features of the book are as follows:

1. Reasons are required for all constructions.
2. A treatment of functional relationship is included.
3. Methods of thinking are stressed.
4. Numerical trigonometry is treated.
5. New type tests are used.
6. Material on the history of geometry is included.

The book will be welcomed by teachers as an important addition to the teaching materials of plane and solid geometry.

C. A. Stone.

Mathematics For Junior High School Teachers, by William L. Schaaf, Department of Mathematics, Preparatory High School, College of the City of New York. Pages xiii+439. Johnson Publishing Company, New York, 1931.

This book is an attempt to offer professionalized materials for mathematics teachers in the junior high school. Thus it presents not only methods of teaching junior high school mathematics, but it skillfully combines psychology, methodology, and subject matter. The material comprises eighteen units each of which is treated by discussing separately, the pupil content, the teachers material, the cultural background for the teacher, educational values, the psychology involved, and the classroom technique.

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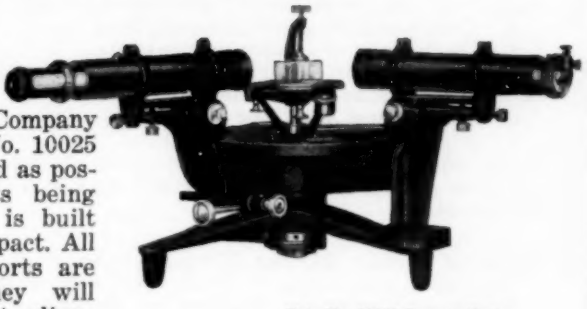

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7. Discussion of educational values.

The book contains a wealth of material and should be a very valuable aid in conducting teachers courses in junior high school mathematics.

C. A. Stone.

Standard Service Algebra Work-Book, by F. B. Knight, College of Education, University of Iowa, Iowa City, G. M. Ruch, College of Education, University of California, Berkeley, California, and H. W. McCulloch, Supt. of Schools, Chatsworth, Illinois. Pages ii+78, 1930. Scott, Foresman and Company, Chicago. Price 44c.

This work-book contains thirty drills designed to review the pupil on important topics of algebra. The drills are preceded by a series of short preliminary lessons which deal with the essential facts and ideas which form the basis for work in algebra. The material is introduced gradually so that the student will not suddenly find himself in advance of his text book.

At the end of each drill are standards of achievement with which pupils can compare their own accomplishments. A corrective section then follows. Here the pupil is to do all work missed or omitted in the drills.

After every fifth drill will be found a *Discussion Unit* which is based on difficult material in the drills. Thus additional drill is given on the more difficult parts of algebra. At the end of the book will be found a progress chart for keeping a record of pupil progress. The book can be used with any type of algebra text.

C. A. Stone.

My Work Book in Arithmetic, Book 6, by Garry Cleveland Myers, Cleveland College, Western Reserve University, and Caroline Elizabeth Myers. Pages 160. 1930. The Harter Publishing Company, Cleveland, Ohio.

In this book decimals and percentage are presented in a very interesting manner. Before the above topics are introduced, the more difficult parts of addition, subtraction, multiplication and division are reviewed. The materials are presented gradually thus enabling the pupil to master facts and processes thoroughly. Throughout the book the authors emphasize accuracy, and advocate that pupils be penalized for making errors.

The book contains 88 exercises and 25 tests. There are many interesting illustrations which make the book attractive. The work book should appeal to teachers who desire to present 6th grade arithmetic in an interesting manner.

C. A. Stone.

Work Book in Algebra, Part II, by Garry Cleveland Myers, Cleveland College, Western Reserve University, Cleveland, Ohio, Elizabeth J. Thomas, Patrick Henry Junior High School, Cleveland, Ohio, and Kimber M Persing, Glenville High School, Cleveland, Ohio. Pages 144. 1930. The Harter Publishing Company, Cleveland, Ohio.

This book is a continuation of the work presented in Book I, and contains materials from fractions in algebra through quadratics. Before the topic of fractions is introduced about 17 pages are devoted to a review of the material presented in the previous book. Each

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exercise is introduced by several worked out examples, and one feels that these could have been omitted since the pupil can get the required explanations from his text.

A careful examination of the book reveals that the topics of algebra have been treated in great detail. However, the material has been crowded and in many instances very little space has been left in the book for the pupil's work, thus necessitating the use of scratch paper.

At the end of the book are found 21 tests based on the subject matter therein. They are traditional in type and are really review materials rather than tests. In the preface the authors state that in developing the work book they have had in mind a basal text in algebra and also a book which may be used as supplementary to any algebra text. One can readily see that such an arrangement may lead to many complications in learning.

The book is attractive and should find favor with teachers who need such a device.

C. A. Stone.

The Theory of the Volterra Integral Equation of Second Kind, by Harold Thayer Davis, Associate Professor of Mathematics, Indiana University. Pages 76. 1930. Indiana University Studies, Vol. 17, Study Nos. 88, 89, 90.

This study deals with the solution of the integral equation of the

$$u(x) = f(x) + \lambda \int_a^x K(x, t)\, u(t)\, dt,$$

where $K(x, t)$, called the kernel, and $f(x)$ are known functions, λ is a parameter and $u(x)$ is the unknown function to be determined from the equation.

Integral equations in general have important applications to a number of branches of pure mathematics and of mathematical physics, as, for example, to differential equations, calculus of variations, potential theory, theory of vibrating strings, thermodynamics, etc. In particular, the Volterra equation treated here appeared in the work of S. Poisson in 1823 in connection with his theory of induced magnetism.

The first part of the book deals mainly with the methods of Volterra and with certain other specialized devices used in solving the equation and the second part is devoted to the study of the singular integral equation in which either the lower limit of the integral is infinite or the kernel is discontinuous. The study is supplementary to a former paper by the author entitled "A Survey of Methods for the Inversion of Integrals of Volterra Type."

Although a previous knowledge of the theory of integral equations is not necessary in order to read the book, a thorough grounding in the theory of integration and of infinite series is essential. The book is a model of clear mathematical exposition, which fact, aside from the information contained, makes it a pleasure to read.

G. E. Raynor.

Problems in Physics for Technical Schools, Colleges, and Universities, by William D. Henderson, formerly Associate Professor of Physics, now Director, University Extension Division, University of Michigan. Second Edition. Cloth. Pages ix+245. 14.5xcm. 1931. McGraw-Hill Book Company, 370 Seventh Avenue, New York. Price $2.25.

This is a very useful supplementary book for students of general college physics. Too often the student follows his regular text book trying to commit to memory enough definitions and principles to pass and may thus get through the course without having learned to think for himself. Such a book as this will stimulate correct study and teach the student to use his text as an aid to clear thinking.

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The reviewer has made use of the book for supplementary problems in summer school classes and highly recommends it to others who have need for ready made problem material. G. W. W.

This Mechanical World, An Introduction to Popular Physics, by Morton Mott-Smith. Illustrated by Emil Kosa, Jr. Cloth. Pages xvi+233. 12.5x19 cm. 1931. D. Appleton and Company, 35 West 32nd Street, New York. Price $2.00.

This is another of the Appleton New World of Science Series designed to stimulate science reading and carry scientific education to everyone. In this book the author has succeeded admirably in giving an understandable discussion of many of the principles of mechanics without resort to mathematical terminology and formulae. He has drawn freely from the history of the development of knowledge of the principles of mechanics and has used many spectacular incidents as illustrations. If you have difficulty in getting your boys and girls to think, give them this book to read; but be prepared for a volley of questions. G. W. W.

Experimental Mechanics by A. Frederick Collins, F. R. A S. Illustrated. Cloth. Pages xvi+302. 12.5x18.5 cm. 1931. D. Appleton and Company, 35 West 32nd Street, New York, price $2.00.

Do you have students who do not care for the regular science class routine but who are continually bringing up troublesome questions about how this or that common implement or machine operates? Here is a book for such boys. It tells them how it works. It shows how to make models from pasteboard, pins and pieces of wood. It explains dozens of things a general science teacher is supposed to know—how the diffential of an automobile works, how the speedometer operates, how clocks are built. It contains a chapter on lock mechanisms, one on measuring instruments, and another describing all sorts of applications of friction. There is even a chapter exploding the various types of perpetual motion machines. The book will provide many optional questions or projects for the rapid workers. It is well illustrated and clearly written—a good book for the high school science library. G. W. W.

BOOKS RECEIVED.

A Shorter Course in Organic Chemistry by J. C. Colbert, Assistant Professor of Chemistry in the State University of Oklahoma. Cloth. Pages xviii+352. 14.5x22 cm. 1931. The Century Company, 353 Fourth Avenue, New York. Price $3.60.

Education for Business by Leverett S. Lyon, Director of Educational Activities and Public Relations, The Brookings Institution, Washingon, D. C. Third Edition. Cloth. Pages xvi+586. 13.5x20.5 cm. 1931. The University of Chicago Press, Chicago, Illinois. Price $3.50.

Second Digest or Investigations in the Teaching of Science by Francis D. Curtis, Associate Professor of Secondary Education and

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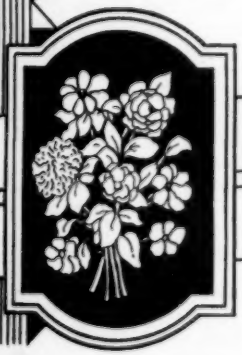

BOTANICAL PRODUCTS

of the Teaching of Science, University of Michigan, and Head of the Department of Science in the University High School. Cloth. Pages xx+424, 13x19.5 cm. 1931. P. Blakiston's Son and Company, Inc., 1012 Walnut Street, Philadelphia, Pa. Price $3.00.

The Principles of Organic Chemistry by James F. Norris, Professor of Organic Chemistry, Massachusetts Institute of Technology. Third Edition. Cloth. Pages xii+595. 14x20.5 cm. 1931. McGraw-Hill Book Company, Inc., 370 Seventh Avenue, New York. Price $3.00.

Experimental Mechanics by A. Frederick Collins, F. R. A. S. Illustrated. Cloth. Pages xvi+302. 12.5x18.5 cm. 1931. D. Appleton and Company, 35 West 32nd Street, New York. Price $2.00.

Chemistry for Students of Agriculture and Home Economics by Robin Charles Burrell, Assistant Professor of Agricultural Chemistry, The Ohio State University. First Edition. Cloth. Pages xviii+459. 14x20.5 cm. 1931. McGraw-Hill Book Company, Inc., 370 Seventh Avenue, New York. Price $3.50.

The First Course in Quantitative Analysis, Containing a Group of Lectures and Laboratory Experiments by Floyd Hamilton Fish, Professor of Analytical Chemistry, The Virginia Polytechnic Institute. Cloth. Pages x+120. 19x13 cm. 1931. P. Blakiston's Son and Company, Inc., 1012 Walnut Street, Philadelphia, Pa. Price $1.25.

A History of Chemistry by J. F. Moore, Late Professor of Organic Chemistry in the Massachusetts Institute of Technology, Revision prepared by William T. Hall, Associate Professor of Analytical Chemistry in the Massachusetts Institute of Technology. Second Edition. Cloth. Pages xxiii+324. 13.5x20.5 cm. 1931. McGraw-Hill Book Company, Inc., 370 Seventh Avenue, New York, N. Y. Price $3.00.

Introduction to the Use of Standard Tests, A Brief Manual in the use of Test of both Ability and Achievement in the School Subjects by Sidney L. Pressey, Professor of Psychology, The Ohio State University and Luella Cole Pressey, Assistant Professor of Psychology, The Ohio State University. Revised Edition. Cloth. Pages vi+266. 12.5x20 cm. 1931. World Book Company, Yonkers-on-Hudson, New York. Price $1.80.

Physical Science, An Introduction to the Specialized Courses in College Science by Herbert Brownell, Professor of the Technique of Instruction in Science, Teachers College, University of Nebraska. First Edition. Cloth. Pages xiv+313. 14.5x23 cm. 1931. McGraw-Hill Book Company, Inc., 370 Seventh Avenue, New York. Price $2.50.

A Laboratory Course in Everyday Physics by Carleton John Lynde, Ph.D. Teachers College, Columbia University, New York City. Cloth. Pages xvii+205. 12.5x19 cm. 1931. The Macmillan Company, 60 Fifth Avenue, New York. Price $1.00.

Seed Dispersal, A Student-Made Book edited by William A. Matheny, Professor of Civic Biology and Botany, Ohio University. Cloth. 141 pages. 13x19 cm. 1931. The Slingerland Comstock Company, Ithaca, New York. Price $1.50.

A Manual of Experiments and Projects in Physics by H. Clyde Krenerick, North Division High School, Milwaukee, Wisconsin. Paper. Pages vii+184. 13x18.5 cm. 1931. D. C. Heath and Company, 285 Columbus Avenue, Boston, Massachusetts. Price 84 cents.

Forest Facts for Schools by Charles Lathrop Pack and Tom Gill. Cloth. Pages x+336. 13x19.5 cm. 1931. The Macmillan Company, 60 Fifth Avenue, New York. Price $1.00.

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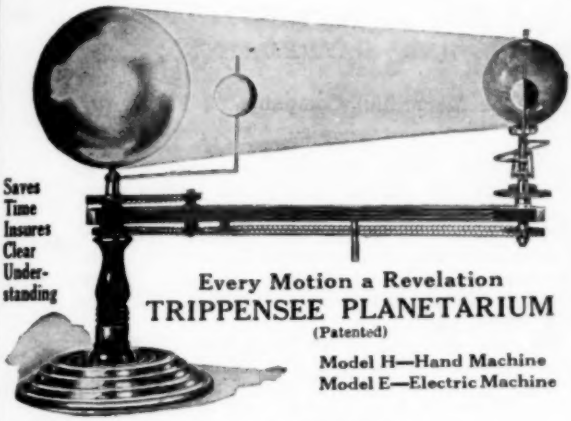

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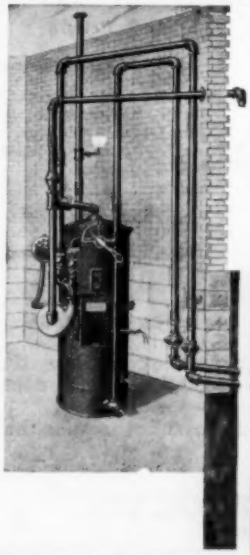

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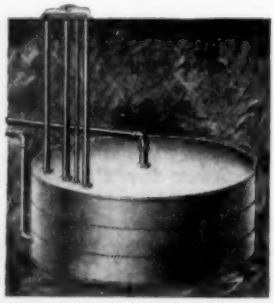

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